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A DECISION SUPPORT SYSTEM TO ASSIST MANPOWER FORECASTING IN THE ROYAL AUSTRALIAN AIR FORCE

THESIS

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The opinions and conclusions in this paper are those of the author and are not intended to represent the official position of the DOD, USAF, or any other government agency.

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Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Logistics Management

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September 1991

Preface

The purpose of this study was to provide a tool to assist RAAF manpower planners and personnel managers with force structure problems. I hope the tool I have developed will be of benefit to them.

My thanks to Capt Jon Determan, USAF, for partnering me in the LOGM615 Logistics Decision Support Systems project which formed the backbone of the core DSS given to several RAAF areas for evaluation and comment.

Thank you to SQNLDR Richard Fogg, RAAF and FLTLT C.F. Lyle, RAAF for their help with the Australian end of the research. Their help was greatly appreciated.

My thanks, also, to Lt Col Larry Emmelhainz, USAF, my thesis advisor. His continued guidance and suggestions have kept me moving in the right direction at all times.

Finally, thanks to my wife, Margaret, for her continued support throughout my graduate program at the Air Force Institute of Technology, and to the five little Kellys for giving me time on the computer during the 15 months.

Simon Kelly

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Abstract

This study considers a problem that faces Royal Australian Air Force (RAAF) manpower and personnel managers. Informed decisions on the future force structure of the RAAF officer corps can be made by managers if they have access to objective, valid, reliable forecasts. At present, the RAAF has no standard mechanism to perform forecasts--a variety of tools are used. Given the importance and cost of the manpower resource, one integrated forecasting tool would support manpower decisions greatly.

The aim of this research is to address the existing forecasting deficiency in the RAAF and provide an automated system to integrate current forecasting methods. A Decision Support System (DSS) is best suited to this task.

A prototype of the DSS, which contained the core modules of the system, was evaluated by RAAF manpower managers. They found the DSS a useful tool to assist them with decisions effecting the future force structure.

A DECISION SUPPORT SYSTEM

TO ASSIST MANPOWER FORECASTING

IN THE ROYAL AUSTRALIAN AIR FORCE

I. Introduction

General Issue

Many military services around the world, including the Royal Australian Air Force (RAAF), have experienced problems retaining experienced officers. Recently, the loss of experienced officers has been higher than normal and the resulting deficiencies have caused numerous manpower difficulties.

The RAAF has had manning deficiencies for many years in various branches at certain rank levels. For example, the Supply Branch and Engineering Branches have grudgingly tolerated manning deficiencies of 20% and 21% respectively for a number of years (34:1). These branches have borne the deficiencies until now, but the recent accelerated losses have aggravated the situation.

Other relatively stable areas within the RAAF have also been affected by the recent increased loss rates. The sound organizational structure of these areas has become

distorted, particularly at the middle management level, that is, squadron leader and wing commander (see Appendix A for rank equivalent charts). An example is the shortfall in 1988 of 77 General Duties Officers (GD), pilots and navigators, at the middle management level (34:9). This represents a shortfall of 17% in a branch of the service that had been fully manned prior to that time.

The effects of these losses have been studied by Cross who reported that the effects can impact on the organization in the following ways:

a. increased costs (it costs $2.0M to train a pilot to an operational level),

b. training problems caused by a lower level of experience and a higher throughput,

c. a diversion of manpower from operational tasks to support the recruiting and training requirements,

d. a dilution of experience,

e. a decrease in the organizational health due to increased job rotation and workload,

f. a loss of morale, and

g. reactive personnel management rather than planned career management (12:76-101).

A number of these factors have a multiplier effect on the loss rate. For example, greater rotation leads to more separations which in turn leads to even greater rotation.

The RAAF, like most military services of the world, but unlike most non-military organizations, has a closed

personnel system. That is, it uses vertical recruitment. Vertical recruitment, as seen in Figure 1, is the system whereby all personnel join at the most junior rank and gradually work their way up through the hierarchy (34:12). The only method of getting to the rank of group captain is by starting at the bottom and working your way up. The RAAF does not laterally recruit personnel into the organizational hierarchy (except in extremely small numbers).

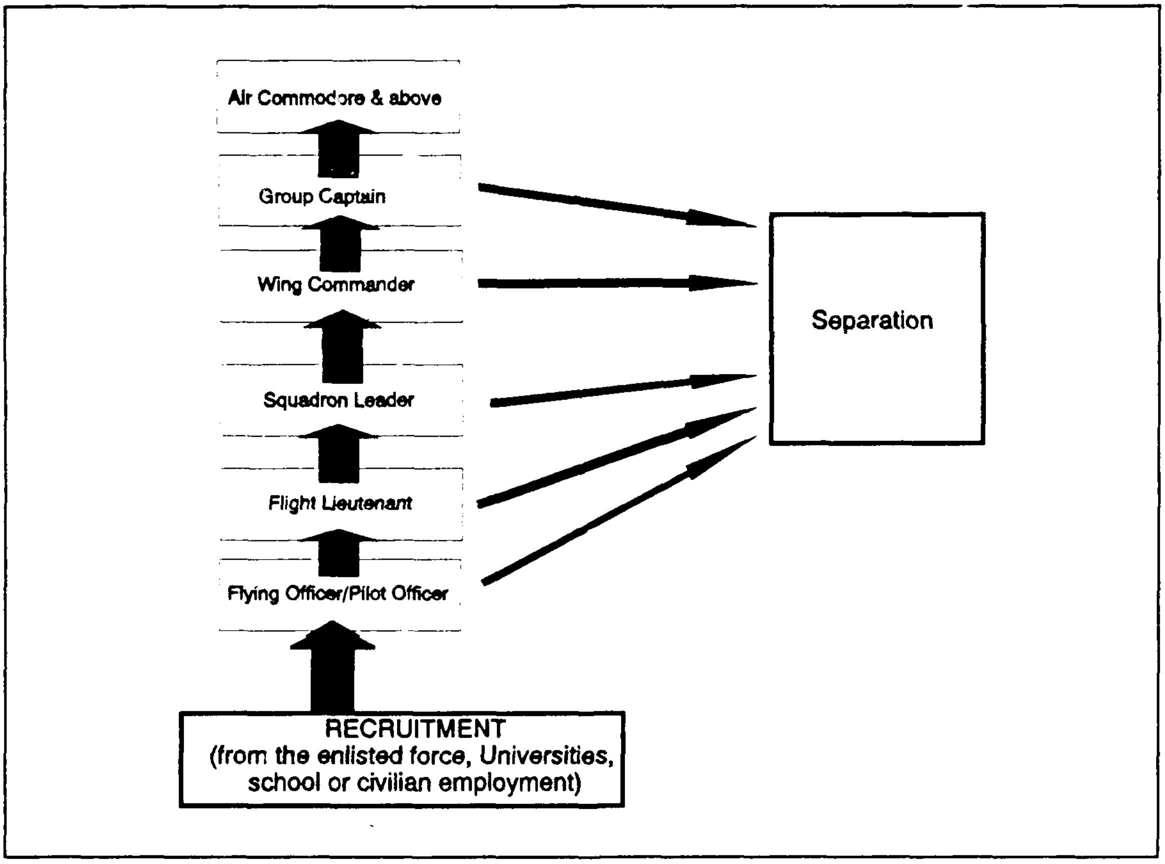

Figure 1. The Vertical Recruitment Method

This recruitment method combined with minimum service time at each level ensures that all personnel have had adequate training and experience before being promoted. A

vacancy at senior level is filled by the promotion of someone from the next level down. This promotion creates a vacancy at the lower level and so the process repeats itself. This continues until someone is recruited to fill the most junior position.

Due to the relatively small size of the RAAF Officer Corps (3,500 officers) and the closed personnel system used, the officer promotion pool at the squadron leader/wing commander levels is very small (34:12-15). This small selection pool limits the ability of higher management to correct any structural problems in the short term.

Problems with the RAAF Officer structure and the cause of these problems have been examined in a number of Defense reports over the years. Among those reports are the RAAF Organization Review Committee report in 1978, the Joint Committee on Foreign Affairs report titled "*Personnel Wastage in the Australian Defence Force-Report and Recommendations*" (the *Cross* report) in 1988, and the DCAS Study Team Report on the RAAF Officer Manning Deficiencies report (the *Tuckwell/Ford* report) in 1989. The RAAF Organization Review Committee report was concerned with identifying the optimal organizational structure to support operational capability. The report found the structure was not optimal and that the branch system reduced flexibility and communication. Follow-up papers argued against this, pointing out the RAAF dependence on technology and the resulting need for specialization. The Cross report looked

at wastage in the whole Australian Defence Force, its effects on capability and suggested measures to reduce the wastage (12:6). The Tuckwell/Ford report dealt with the higher than average separation rates from the RAAF. It was specifically "undertaken to address the measures which would be necessary in the longer term" (34:1). Each report commented that action was required to reduce organizational structural problems.

Reports such as these, and other papers, have not only highlighted problems but have suggested changes to correct or improve the RAAF Officer structure. The RAAF Officer Manning Deficienci.. report recommended 19 measures to improve retention of officers and the Cross report listed 48 recommendations for change. Some of the recommendations were:

a. age requirement changes at both entry and retirement points,

b. the introduction of a location stability scheme,

c. the introduction of a "perks" package,

d. an increase in the defence housing loan, and

e. the introduction of a new superannuation scheme, not based on 20 years of service (12; 34).

One factor, and often a major one, considered by RAAF management before implementing proposed changes is the long term effect that these changes will have on the structure of the force. Such predictions are made individually for each initiative without the use of any standardized methodology

or specialist agency. Sometimes the ramifications are calculated manually, at other times a spreadsheet is used, and occasionally a computer model is built. The staff using these methods have varying levels of expertise and use different frames of reference.

Specific Problem

To make informed decisions, management would like access to objective, valid, and reliable forecasts, each based on the same frame of reference. Currently, there is no standard mechanism used to predict the impact of proposed changes to the Officer Corps manpower of the Royal Australian Air Force. The varying methods used make comparison of alternatives extremely difficult and hence decisions to implement change or construe a priority list cannot be done with any confidence.

Previous Work in RAAF Manpower Modelling

In 1982, WGCDR Christopher Mills formulated the RAAF Officer Structure (ROS) model as part of his Master's thesis at the USAF Institute of Technology (26). While this simulation model provided good long term forecasts, it was implemented on a mainframe computer. Access to this computer was difficult, response times were long and computer specialists were required to assist with the data input and evaluation of results. The impracticability of the model negated its usefulness as a decision tool and the

ROS model is no longer used by RAAF personnel managers.

In 1990 the Director of Manpower Planning and Control, GPCAPT Nixon, wrote a paper which addressed the structural problems within the RAAF and proposed a policy for management of category structures. In this paper he developed a model which calculated the number of positions required at one level of the organization to support and sustain the rank structure at the next level (27:5). He presented this structure as the "ideal" structure. At the present time, the model is limited in its use as a management tool as it makes a number of assumptions based on present personnel policy and it was not designed for "what-if" analysis. A system that allows quick comparison of suggested structural changes combined with the output produced by the Nixon model would provide a valuable tool for management.

Research Objective

The overall objective of this research is to develop a system that supports decision making in the area of manpower structure and to determine whether it addresses the lack of an integrated forecasting system. This objective can be divided into two distinct sub-objectives: developing a system and determining whether it addresses the problem. The system developed must aid RAAF managers in their decision making. To achieve this, it must provide information on how changes will affect the structure of the

RAAF Officer Corps. The developed system should allow selection of parameters which are significant to the structure; a process for modelling the structure; and an appropriate form of output. The second objective is to determine whether the developed system properly addresses the lack of an integrated decision support tool. To achieve this objective, the information provided by the system must use current data; be able to be manipulated by the manager; and be able to provide usable and timely information.

Research Questions

In order to achieve these objectives the following investigative questions need to be answered:

a. What is the best way to provide a manpower structure modelling capability? Is it by using a simulation model, an analytical mathematical model, or some other method?

b. Would a decision support system be an appropriate method of providing the management support required?

c. What factors are significant and how do they interact in the manpower structure? Can these factors be incorporated into the models?

d. What information is required by management to support decision making in this area? In what form is the information required?

e. To what extent does the system allow management to solve this problem?

Justification of the Research

Experienced personnel have often been described as the most valuable asset of an organization. This is certainly true in the RAAF. Experienced personnel are a scarcity and an expensive resource to obtain. This situation is likely to continue for the foreseeable future. As with any scarce resource it should be closely monitored. The research proposed by this thesis will help the resource monitoring process and aid management in decision making concerning the resource.

As Cross has stated, there are costs to the Australian Defence Force, and particularly the RAAF, in not having enough people but there are also high costs involved with having too many people. At such times, there is no benefit to be gained from training a pilot at a cost of $2.0M if he is not required and the structure cannot really support him.

To ensure effective use of valuable resources, management must observe them closely. However, a tool for monitoring is not presently available. If the RAAF can retain one extra pilot or not recruit one using the system proposed in this research then the system should prove to be cost effective.

Scope of the Research

The research is not concerned with *why* questions. It is only concerned with *how* the parameters interact. The research will not be trying to justify the present numbers and type of personnel at each of the levels. These are operational or political decisions and beyond the scope of the thesis. The research will, however, investigate how changing an input parameter affects the system, that is, how changing the initial conditions affects the shape of the pyramid over time and what the new shape will be. An example of the shape of the present RAAF structure is given in Figure 2. The distinctive pyramid shape can be seen. Note, also, the surplus of FLTLTs and the shortage of SQNLDRs and WGCDRs.

The system being developed is aimed at managers in the Directorate of Personnel-Officers (DPO-AF) and the Directorate of Manpower Planning and Control (DMPC-AF). Most of these managers have easy access to, and are competent users of, IBM PC microcomputers. Some of these officers also have access to a Hewlett-Packard HP3000/935 mini computer. Since the researcher does not have access to a HP3000 mini computer, the system will be designed for implementation on an IBM PC microcomputer. The choice of a microcomputer also increases the range of software options, allows the use of a graphic interface, eases transportability and allows more validation during development.

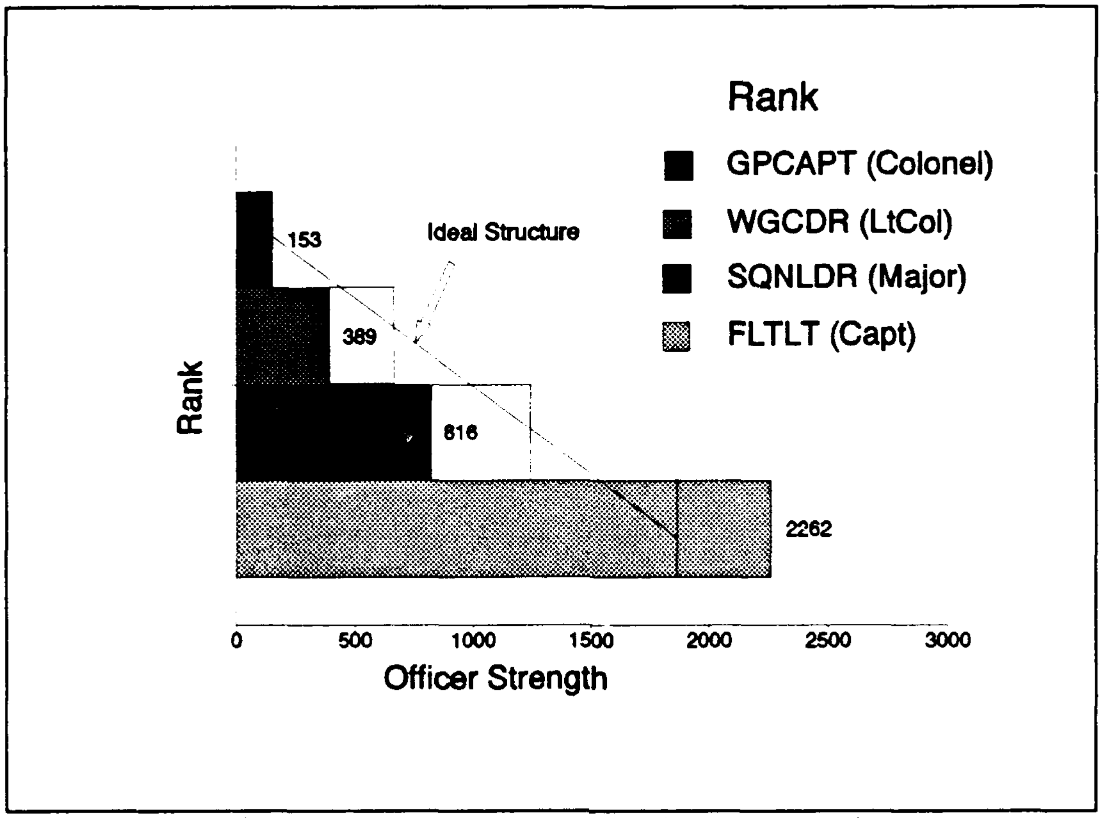

Figure 2. The RAAF Officer Pyramid

Limitations

The research is being conducted in the USA while the intended users are located in Australia. This limits the amount of contact and correspondence between the researcher and the intended users. While liberal use of telephone and mail services between the countries should lessen this limitation, there is still likely to be some impact.

Definitions

The following definitions refer to fundamental terms that will be used throughout the thesis. The definitions are included here to ensure that the reader and researcher

are using the words with the same interpretation. Operational definitions are given for most of the terms.

RAAF Officer Corps. The RAAF Officer Corps is made up of six branches--General Duties, Special Duties, Engineers, Supply, Medical and Chaplains--plus an uncategorized group. The chaplain branch is quite small and has a unique promotion system. It will not be looked at in this research.

Within each of these branches are categories. An example of the categories is the breakdown of engineers into aeronautical, electrical, mechanical and armory. In addition to these horizontal divisions the officer structure is divided vertically by rank. Starting at the most junior rank, the ascending order is pilot officer, flying officer, flight lieutenant, squadron leader, wing commander, group captain, air commodore, air vice marshall and air marshall. Appendix A has rank equivalent charts for other military services.

Separation Rate. Separation rate is the term used to cover all discharges from the service in a given period. It includes failed trainees, administrative discharges, resignations, retirements and deaths.

Decision Support System. The term decision support system (DSS) refers to "systems that are designed to help managers evaluate and analyze complex situations" (14:xv). A DSS should be user friendly, use current data, be

reliable, be flexible, and provide robust answers for varying situations (14:54-56).

Manpower Management. Manpower management is "*formulating, choosing, and implementing policies affecting the manpower and personnel of an organization while supporting the goals and objectives of the organization*" (24:5).

Manpower Planning. Manpower planning is a subset of manpower management and has the purpose of producing the correct number and correct types of people at the correct time. Grinold and Marshall view manpower planning from a different perspective. They state "*A more realistic view of manpower planning is that it avoids having too many of the wrong types of people in the wrong jobs too frequently*" (22:xix).

Modelling. A model is a description or representation of some system. The intended purpose of the model is to explain, understand or predict the behavior of the system. The model will normally simplify the real system (7:2; 30:4).

Simulation. Simulation is the imitation of the operation of a real-world process over time. Simulation involves the generation of "artificial history" of a system, and observation of that artificial history to draw inferences concerning the operating characteristics of the real system. The behavior of the system is studied by developing a model (4:2).

Verification. Verification is the process of checking that the model operates in the way the researcher thinks it should (7:8).

Validation. Validation is the process of checking that the model is a sufficiently close approximation to reality for the intended application (7:8).

Thesis Structure

The objectives of this thesis--to develop a system that supports decision making in the area of manpower structure and to determine whether it addresses the lack of an integrated forecasting system--will be dealt with in the remaining chapters. Chapter II will review the broad range of literature that covers manpower modelling, the selection of significant parameters, and the use of decision support systems. Chapter III will present the methodology to be used in achieving the research objectives. The methodology used to develop the system will involve scenario entry, database access, modelling, simulation and result presentation. Validation and verification of the model throughout the development process will ensure it meets the second objective--that it addresses the problem. Chapter IV will present findings and analysis. A description of how the system was developed, the validation process and results, and how well it achieves the objectives will be offered. Chapter V will conclude the thesis and make recommendations for further study.

II. Literature Review

Introduction

The continual monitoring and reevaluation of priorities is necessary with any resource. This is especially true for a scarce, costly resource such as manpower. The importance of manpower was highlighted by Air Vice Marshal Reed, in an interview before his retirement, when he said, "People are your most important asset. Encourage, entrust, empower and enable them to do what is needed" (2). Jaquette, Nelson and Smith present two major reasons to justify the importance of manpower management. Firstly, manpower costs consume a large proportion of the DoD budget (40% in 1988) and, secondly, there is a limited manpower pool from which the Air Force must draw its resources (24:v). Other authors have noted that the youth pool is gradually decreasing as the average age of the population increases (3:5; 5:10). These reasons for carefully managing manpower are equally true for Australia. Australia spent 43.3% of its Defence budget in 1988/89 on manpower (15:117) and the RAAF has not been able to achieve its total officer recruiting goals for a number of years (34:168).

The tasks of making effective and efficient use of the manpower resource in the RAAF are performed by two organizations within the RAAF. The Directorate of Manpower Planning and Control (DMPC-AF) is concerned with the

determination of manpower needs to accomplish the service's objectives and, therefore, looks at the overall or macro level ("spaces"). The Directorate of Personnel-Officers (DPO-AF) is responsible for the micro level. DPO-AF assigns personnel to each position authorized by DMPC-AF ("matching faces to spaces").

A forecast of future RAAF structure needs to consider many factors. These include present force size, personnel policy, promotion policy, and other external factors. The inherent complexity of these factors, make any forecasts and decisions based on the forecasts, very subjective. Computer based decision support systems (DSSs) are designed to support and expedite decisions of this type. DSSs help bring structure to complex problems and enable the manager to more fully understand the implications of a certain course of action (16:289). The support offered by DSSs should lead to better decisions (or at least more informed decisions).

This chapter will review literature which has examined forecasting and management of manpower through the use of models and DSSs. The literature review will provide answers to three of the research questions from Chapter I, namely:

Question One. What is the best way to provide a manpower structure modelling capability? Is it by using a simulation model, an analytical mathematical model, or some other method?

Question Two. Would a decision support system be an appropriate method of providing the management support required?

Question Three. What factors are significant and how do they interact in the manpower structure? Can these factors be incorporated into the models?

The first question will be addressed by looking at the modelling of manpower and the types of models applicable. The background of decision support systems, their components and functions and the areas to which they are suited will then be presented, to allow an evaluation of DSS for this project. The remainder of the chapter will look at the final question--the factors important to manpower modelling.

Modelling and Manpower

In chapter I, manpower management was defined as the formulating, choosing, and implementing of policies affecting the manpower and personnel of an organization while supporting the goals and objectives of that organization. The United States Department of Defense, amongst others, has recognized for sometime the importance of manpower as a resource, and employs the use of models in its manpower management. The use of models is highlighted by a 1973 Rand report which identified over 200 manpower and personnel management models in use (9). The Australian Defence Force also makes use of models in the support of

manpower management but not to the same extent as the United States DoD.

WGCDR Mills in his 1982 master's thesis examined some of the manpower models in use in the Australian Department of Defence (26:43-52). The majority of these models, including the RAAF Officer Structure (ROS) model developed by Mills and others, were based on Univac mainframe computers operated by one central defence computing agency, Computer Systems Division (CSD). The forecasting models relied heavily on historical data also held on these CSD computers. Since that time, CSD has been dissolved and the management of the computers has been transferred. The role of the CSD mainframe computers changed, with the change in ownership, to that of a management information system (MIS). The databases have been retained but the modelling is no longer performed. The responsibility for modelling appears to have fallen on each individual service, although this responsibility is not clearly defined.

The models in current use within the RAAF are based on computer spreadsheets and are designed to be operated by specialist officers. One is the POMANPLANS model in DPO-AF. This model is used for forecasting recruiting requirements and other related tasks. The model uses data from the Officer Category Situation (CATSIT) report to do its forecasting. All data on personnel is stored in the AFPEMS database, a minicomputer database of all RAAF personnel. Periodically, summary data is extracted from the AFPEMS

database for use in the CATSIT database. One physical computer is used to extract the data from the AFPEMS database, to hold the CATSIT database, and to do the POMANPLANS forecasts. This allows integration and automation of parts of the system. However, the POMANPLANS model is not designed to be used by managers for decision making but rather for the completion of specific tasks within DPO-AF; these tasks require specialist operation and interpretation.

Another spreadsheet model used is the Nixon model discussed in Chapter I. This model was developed by GPCAPT Nixon for DMPC-AF in response to structural problems within the RAAF in the late 1980s. He proposed a mathematical model which calculated the number of positions required at one level of the organization to support and sustain the rank structure at the next level (27:5). The spreadsheet model used by DMPC-AF is an implementation of this mathematical model. Presently, this model is of a specialist nature and not designed for managerial "what-if" analysis.

Both models were designed for a specific purpose and for use by a specialist. Neither is suitable for use as a general decision aid for managers.

Other manpower models can be chosen according to classification. The criteria for one classification is based on "technique used to model". A popular technique category is Inventory Projection Models (IPMs) (8:34;

38:133-147). IPMs use the notion that the number of people that make up the structure of an organization can be thought of as the inventory of that service. There are a number of factors that influence the size and type of this inventory. The factors include present size and type, the rate of input, the rate of movement through the system and the rate of output. The parallel between inventory and manpower can be seen by equating size and type with category and rank; rate of input with recruitment rate; rate of movement with rate of promotion; and rate of output with rate of separation.

The IPM technique is used in a number of computer models--Markovian models, simulation models, econometric models, assignment models, network models, queueing models, and renewal theory models are just a few that have been built and successfully used (38:114-120; 14:137; 22).

The amount of realism that is incorporated into an inventory model depends on the detail that is "mapped" from the real world into the model. The detail required depends on the application of the model. To have complete realism, a model would require vast amounts of time, computing resources, money, and specialists. Conceivably, the output from such a system may be as complex as the real world and therefore not terribly useful. In general, the complexity of a model will "largely depend on the accuracy and detail with which one wishes to describe future inventories" (8:34).

A second method of classifying personnel models is suggested in a report for the US Navy Personnel Research and Development Laboratory (NPRDL). The criteria for this system is based on "intended use". The report identified three types:

a. Requirement models that calculate the number and type of people required to meet an objective.

b. Assignment models that consider the present force, policies and tasks and allocate the force accordingly.

c. Forecasting models that predict some future event. (24:5-6)

A large number of requirement and assignment models are being used in USAF Command Headquarters to estimate the quantity and quality of personnel required for different projects--allocation of positions then goes to the best suited (28; 19). Areas of application of the assignment models include assignment to courses, equality in overseas tours or equality of career guidance.

Applications of the forecasting models include estimation of future retention rates and projection of future force composition. These forecasting models can be further broken down into two types--optimizing and non-optimizing. An optimizing model uses automatic procedures to find the best solution to a problem given a number of constraints on the problem. Non-optimizing models do not contain any automated optimizing procedures; they are used

"interactively to reach an optimal prescribed by the user's judgement. . . these personnel models allow planners to ask *what-if* questions and evaluate tentative results before actual policies must be determined" (24:11).

In it's report the NPRDL also suggested the comparison of the following attributes when choosing a model: an ideal versus a predictive model, an individual versus an aggregate model, a deterministic versus a stochastic model, a steady-state versus a dynamic model, and an actual versus a derived distribution model (24:12-20).

Ideal vs Predictive. Ideal models provide forecasts under the assumption that policies operate in an ideal environment. These models ignore idiosyncratic points and concentrate on the overall picture. Predictive models operate at the other end of the continuum; they try to represent the real world more accurately and concentrate on detail. Unfortunately, a trade-off comes with the introduction of more variables (to enhance the realism) to the predictive model. More variables induce more variability and the variability increases the bands of error. The increased bands of error reduce the usefulness of longer term forecasts. Given this, predictive models can only be reliably used for short-term predictions. The ideal model with its reduced variability is better suited to long term forecasts. The reduced variability makes the ideal models more consistent but it make the ideal more accurate than the predictive.

Individual vs Aggregate. Using an inventory model, it is possible to represent an organization as a large number of individual items or to aggregate the individuals with similar characteristics and form a smaller number of cells. The individual approach has a greater overhead as each person (item) is required to carry his own list of characteristics. This overhead translates into larger storage and processing power requirements than a similar aggregate system. However, aggregation also has problems. A level of detail is lost through the grouping, which cannot be recovered (24:13-14).

Deterministic vs Stochastic. One of the contributing factors to the size of the inventory is the rate of movement through the system. In the case of manpower, this movement rate represents the amount of time an individual spends at one rank before promotion to the next; or if aggregate cells were used, the percentage of one cell that is promoted in a given period. In the case of aggregation, the rate of movement will depend on the percentage of those at one location who are selected to move on to the next location at a given time. If the percentage is deterministic, the rate can be represented mathematically as

$$\bar{X}_{t+1} = \bar{R} * \bar{X}_t \tag{1}$$

where $\bar{X}$ represents the state of a cell at a given time t and $\bar{R}$ the probability of movement or promotion. $\bar{R}$ is known as the transition matrix. The transition matrix represents a

deterministic process, where the chance of promotion at any given time is known and fixed. Markov models are based on transition matrices of this type. In a Markovian process the movement to the next location is determined only by presence in the current location. A large number of manpower models have successfully used Markovian processes. In contrast to deterministic models, stochastic models are models in which the probability of moving from one location to another has a degree of randomness. The use of randomization normally provides a closer approximation to the real world but this must be traded off against the significantly increased complexity in the model. In general, the introduction of stochastic factors will force the model designer to use simulation rather than analytical modelling.

Steady-State vs Dynamic. In a steady-state system, an equilibrium exists, that is, the number entering a given cell equals the number leaving. In the real world, steady-state is seldom reached so models based on this premise represent an idealized environment. However, the use of steady-state conditions allows the use of analytical mathematical techniques which are not possible in non steady-state or dynamic models. In a dynamic model, the equilibrium assumption is not made. This allows them to more closely approximate the real world but increases the overall model complexity.

Actual vs Derived. If aggregation is adopted over individual, a second decision is required as to the type of distribution of the aggregated cell. Actual figures for the cell can be obtained (by averaging) or a distribution of the numbers in the cell can be derived. The derived figure is normally the steady-state distribution figure.

Examples of Manpower Models in Use

A number of attributes contribute to the realism of a model. This section examines a number of operational systems and their attributes.

The Department of Defense in the United States has a number of operational manpower and personnel models. Some of the models relevant to this project are TOPLINE, DOPMS, OSSM, MLRPS, EFMS and the Dynamic Retention Model. The RAAF has also developed some manpower models including the ROS model and the Nixon model.

TOPLINE. The TOPLINE system was the first operational Air Force personnel model and was developed to assist in "reaching the optimal distribution of Air Force Officers" (24:53). The optimal distribution being described in terms of years of service and grades. TOPLINE is a non-optimizing model (despite the goal of the system) and uses trial-and-error procedures to arrive at an optimal solution. The modeler uses an iterative approach of varying the input factors until the required optimal distribution of the future force is found. TOPLINE is an old, long term

planning model. It has ideal, deterministic, steady-state, aggregate attributes. The model is based on a Markovian process. The transition matrix, used to model the movement of personnel from one level to another, is a mathematical function based on accessions, training rates, length of commitment, force-out years, retention rates, and promotion opportunities for each aggregation cell. The objective of the model is to establish a hypothetical force distributed by grade and years of service (24:53-54).

DOPMS. The Defense Officer Personnel Management System (DOPMS) is primarily a rank management system for officers. This system has superseded TOPLINE as it includes procedures to cost the force and it possesses more flexibility in the way retention rates are defined. These improvements give it a wider applicability than TOPLINE. DOPMS is, again, based on a deterministic, steady-state model. The cells for aggregation are grouped by year, rank, category, procurement source and management category. The procurement source refers to whether entry into the force is via direct entry, ROTC, or service academy (24:57-58).

EFMS. In addition to the TOPLINE model, an enlisted force version was developed called TOPCAP. The Enlisted Force Management System (EFMS) is a new system designed to enhance the capabilities and correct deficiencies in the TOPCAP model. To achieve these goals, EFMS provides the capability to model rank restructuring, personnel planning and programming, while providing the user with more control.

EFMS allows the user to change data, request information, or run the system without the help of a programmer (8:20). EFMS retains the modelling methods of TOPCAP but increases the number of factors that can be input.

OSSM. The Officer Structure Simulation Model (OSSM) was developed by the Air Force Manpower and Personnel Center. While the models mentioned above are rank management tools, OSSM is designed to help with other problems. It comprises a set of three dynamic models designed for specific tasks, such as training requirements and career management. Two of the models are deterministic and aggregate to provide long term trend information. They break the service down by AFSC code (category or specialty code) and provide configurations of the future force. The third model is stochastic and tracks an individual through the system. This is designed to give better short term performance (24:68-69).

MLRPS. The Army Manpower Long Range Planning System (MLRPS) is used to project the strength of the Army up to 20 years into the future. MLRPS has three sections--a database subsystem, a flow model subsystem and an optimizing subsystem. The flow model uses a Markov model to project the flow of the present force into the future. It is a deterministic, steady-state model. The optimizing subsystem allows the specification of a desired final structure by grade and years of service or grade and category. It then determines the transition matrix required to attain this

result. This matrix provides short term targets for achieving the long term structural goal (19).

Dynamic Retention Model. The models above can all be classified as inventory projection models. The Dynamic Retention Model uses a different approach; it looks at the personal characteristics of officers using an econometric approach. This method of forecasting has been found to remove some systematic errors found in inventory models. The Dynamic Retention Model "addresses the tay/leave problem confronting officers: the choice of the optimal time to leave the military" (21:1). The choice to stay or leave is made on the grounds of taste, civilian income opportunities, military income opportunities and random events (such as sickness in the family). The dynamic retention model was designed to estimate the voluntary retention rates under a broad range of compensation, retirement, and personnel policies. It uses a stochastic, individual, dynamic process to achieve these objectives. The output from the model is a prediction of voluntary retention rates for male Air Force Officers.

RAAF Officer Structure Model. The RAAF Officer Structure (ROS) model developed by Mills and others uses an individual, stochastic approach to modelling the force. Since the RAAF officer force is small and the model can handle up to 5000 people, each individual, along with a list of his characteristics, is represented in the simulation model. Time is advanced in yearly steps and with each step,

decisions are made on whether to promote, retain or separate each individual. The model uses a goal seeking approach in an attempt to fill every position with the available personnel. Through this approach, future problem areas can be identified by category, rank or overall strength (26:49-51).

Additional Models. The United States Department of Defense alone, has over 200 manpower models. Some of these have been presented. Most of those not presented are based on the same IPM premise as those discussed above. The premise being that given the size and characteristics of the present inventory of personnel, and historical or expected movement rates, the future inventory can be forecast.

Other models of particular interest are the Nixon model already discussed at the start of this chapter and the POMANPLANS model used by DPO-AF. The Nixon model is an inventory prediction model and is designed to calculate the sustainable officer structure, the "ideal" structure of the RAAF. The POMANPLANS model is also an IPM and is used to calculate recruiting requirements and to make other DPO-AF related forecasts. Both are deterministic models.

Suitability of Modelling to this Research

Manpower models exhibit a range of methods for modelling personnel behavior. Not all of these methods are suitable for this project. The Dynamic Retention Model of Gotz and McCall is sound theoretically (3:31) but is too

narrow in scope to be considered for this project. While retention rates, which the Dynamic Retention model addresses, are a significant factor in the overall process, they are only part of it. In addition, the dynamic retention model requires parameters that are subjective (taste), hard to obtain (civilian income opportunities), and complex (random events). Because of the stochastic nature and complexity of these factors, large variance may be obtained in the results. The large variance restricts its usefulness to short term forecasting. The RAAF requires a mid to long term forecasting tool, so this model is not appropriate. Given that dynamic retention models are complex, most useful in short term forecasting and address only part of the problem being addressed by this research (the retention rate), they will not be used in this project.

The manpower model most commonly used model, and most suited for implementation in the RAAF is the inventory projection model (IPM). There are a variety of model that fall within this classification. The difference between the models is the method used to calculate the throughput. Situations where a broad perspective is required, or situations where the degree of realism is less critical, are modelled using a deterministic, steady state, analytical model. A Markov model is often used in this circumstance. A second type of IPM model is the stochastic, predictive, dynamic model. The main advantage of this model is that it provides a higher degree of realism. However, the increased

accuracy in mapping the real world is achieved through greater complexity. This complexity derives from the introduction of simulation techniques, the requirement for more detailed historic data and the existence of a more intricate model. The increased complexity usually leads to greater variance in solutions which, in turn, makes these models more suitable for short term forecasting.

The objective of this project is to provide a tool that can support management decision making in the area of force structure. As discussed in Chapter I, the RAAF employs a closed personnel system. People join at the most junior officer level and gradually move up as they gain seniority and experience. This closed system, combined with the small officer pool, gives management limited flexibility in the short term (less than one year). A tool is required that will allow early identification of problem areas long before short term dramatic action must be taken. In summary, the system should address the medium to long term (one to five years) rather than the short term. It is primarily concerned with the broad or aggregate effect of decisions rather than the behavior of a particular individual. A reasonable level of realism is required but not to the extent needed if predictions on individuals were made. From the literature reviewed, it appears that an inventory projection model based on a Markovian process provides the appropriate modelling solution.

The discussion above has suggested an answer to the first question posed by this research:

> *What is the best way to provide a manpower structure modelling capability? Is it by using a simulation model, an analytical mathematical model, or some other method?*

For medium to long term decisions within the RAAF an analytical, mathematical model (which considers the manpower force as inventory, with recruitment, promotion and separation rates as throughput) has been widely used and seems the most appropriate method.

Decision Support Systems

Allen and Emmelhainz see a decision support system (DSS) as a computer system designed to aid managers "in making effective decisions in those areas where both management judgement and computer analysis are required" (1:129). Davis suggests that DSSs can be applied in situations where "the complexity of the process exceeds human abilities to visualize the affects and implications of a decision" (14:23). He goes on to suggest three suitable areas of application:

a. many independent activities,

b. a multitude of complex factors, and

c. an extremely complicated relationship between the parts. (14:23)

The manpower models presented in previous sections are

often used to reduce complex problems to a manageable size and aid decisions based on management judgement and data analysis. Problem reduction fits the Davis definition of a DSS and decision help fits the Allen and Emmelhainz definition of a DSS. This correlation tends to suggest that a DSS may be a suitable manpower tool for the RAAF.

A DSS links a user interactively through a computer to both a database and to a modelling system. The link is the critical component in a DSS. It is through this link that the DSS "helps decision makers effectively confront unstructured problems" (16:289). It assists the user to extract data, manipulate a model and interpret the results. This linking mechanism allows a manager to build his own scenario, run the scenario and view the results without computer programmer expertise. It provides an integrated, intelligent and "user friendly" interface between the components. The use of an interactive interface simplifies use of the system, gives the user more control and negates the need for extensive training. The modelling function embedded within a DSS allows a decision maker to do "gaming" or "what-if" analysis and view the results of these scenarios.

Before an evaluation of the effectiveness of a DSS can be made an understanding of the types of decisions made by managers and the methods used is needed.

Types of Decisions. Many authors categorize decisions into two types--structured, and non-structured (17:357).

Other authors label the same types of decisions with other names. Structured decisions are also called programmed or Type I decisions, and unstructured decisions are also known as nonprogrammed or Type II decisions (13:438; 31:198). The determinants of structured decisions can be described in detail. In contrast, an unstructured decision has non-quantifiable variables such as unknown time frames, incomplete knowledge, extensive search area, and subjective data (20:195). Daft and Steers explain that programmed (that is structured) decisions are made "in response to problems that are repetitive and well defined" while nonprogrammed decisions are made "in response to problems that are novel and poorly defined" (13:438). A third type of decision, semi-structured, is sometimes categorized, that covers the ground between these unstructured and structured decisions. In contrast to their naming conventions, all authors agree that the problems become more unstructured as the level of management increases (17:358).

Normal management information systems are aimed at assisting structured problems, but DSSs place more emphasis on utilizing information to improve human effectiveness. In this way the DSS supports, not replaces, human judgement, an essential component in solving unstructured problems. The evolution of DSS that follows will explain in detail how unstructured problems are being addressed.

Evolution. In the last decade or so, assistance with managerial decisions has come from two sources--computers

and management science. Since its initial introduction, computer processing has evolved from basic data processing, to data base management and report generation (31:200), to a "storehouse of knowledge" (1:132). Parallel with this, progress was made in the field of management science. Various models were built to examine and compare problem outcomes. Initial symbolic mathematical models evolved into models that relied on a computer to do the calculations, to modelling systems and finally to interactive modelling (31:201).

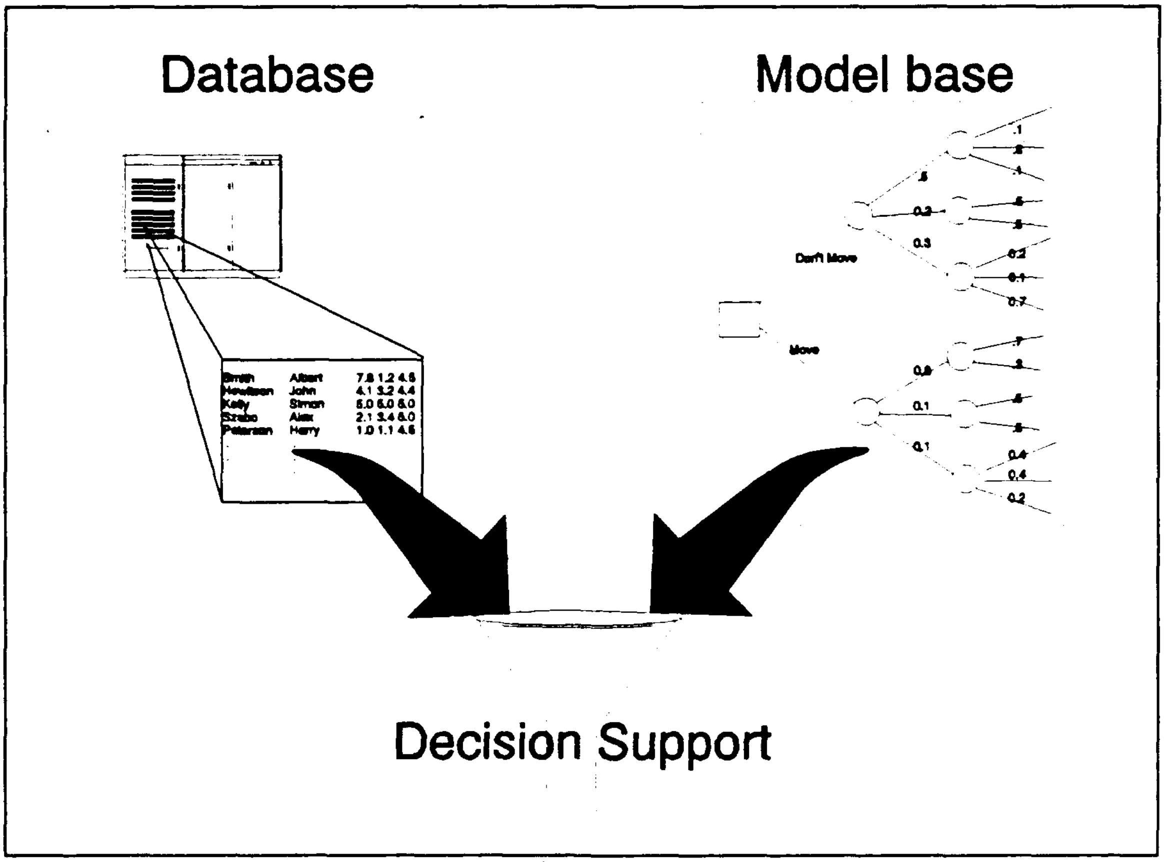

Figure 3. The Blending of Data and Modelling

The final step in the evolution, as seen in Figure 3, was the integration of these two decision aids--modelling and data bases. As Sprague explains:

> *Each of the two development tracks--in data base and in modelling--were useful in their own right. They were each significantly lacking, however, in helping information workers deal with Type II tasks. Developments in Decision Support Systems allowed each set of capabilities to realize their potential in this area. DSS extended and combined both the data base technology and the modelling technology, and gave non-technical users access to them. The data and models were intimately linked, and both were linked with the user.* (31:202)

A structured problem could be tackled and solved by using data or management science models. A DSS which merges the database, the model base and the manager, provides a mechanism to solve semi-structured problems (1:131).

Components and Functions. The components of a DSS, as implied above, are a data base, a model base and an interactive link with the decision maker (37:277). The data base may draw data from various locations. This data may include aggregate data from the basic data processing system, qualitative data from managers, data on policy guidelines, or data on budget limits and estimates. A method of updating and maintaining the database would also be included in the DSS. The model base will include the different analytical models required, and a set of modules for updating or restructuring the models. The importance of the link with the user has already been highlighted. The primary components of this link with the decision maker are the communicating device and the language used. Almost all

modern DSSs use an interactive terminal, such as a color graphic monitor, to help ensure clear communication between the machine and the user. The software language used to link the machine and user needs to be English-like for use by non-computer literate managers yet powerful enough to accommodate detailed work (23:22-29).

The functions required of a DSS to support Type II decision makers are (1) tracking, monitoring and alerting; (2) problem-solving, analysis and design; and (3) communication (31:199). The successful installation of these functions combined with good user dialogue makes a DSS suitable for the following situations: (1) problems that are continuously changing, (2) problems that need answers quickly, (3) continuously changing data from a variety of sources, (4) data that must be processed into different kinds of data representations, and (5) rapid implementation of policy rather than long term efficiency (20:195).

Examples of Manpower DSSs in Use

A good example of a DSS combining the benefits of data base information, modelling and user interface is a massive personnel assignment system designed by Constantopoulos. The problem tackled is described as a decision of the semi-structured type (11:355). It has some structure as the problem can be represented by an assignment model using historical database information. But it is unstructured in that a subjective judgement according to *ad hoc* or

unspecified criteria determines the overall "best" fit. Constantopoulos points out that the DSS aims at "facilitating and enhancing the effectiveness of the . . . unstructured, judgmental part of the process" (11:356). The DSS is helping to bring structure to a problem which was originally unstructured due to it's complexity.

Venema and Wessels present a manpower modelling DSS that appears to be closely related to this research (36). They explain that their DSS translates the scenario given by the user into a model and then analyzes or simulates the situation using database information. The DSS provides an overview of the results of the different scenarios. The interactive link allows the user to enter the initial scenario and then view the results. These results may lead to further scenarios (36:503) which are easily entered via the link. Again the integration of modelling, database and user are evident in its attempt to solve complex problems.

Suitability of a DSS to this Research

A previous section gave the components of a DSS as a database, a model base and an interactive link with the decision maker. Through the interaction of these components, the DSS helps the decision maker "effectively confront unstructured problems" (16:289). The components found in a DSS are the same elements as those required by RAAF managers to support their decision making. All manpower decisions use historic data, trend data and policy

data to some extent. Examples are that the average time in rank before promotion and the present officer structure are derived from aggregated historic personnel data; that the minimum time in rank and the length of obligation after promotion come from personnel policy data; and that the maximum separation rate that can be expected comes from expert opinion. A database is a suitable receptacle for holding and manipulating this information. To forecast the future some kind of model is required. A model base that is available to multiple users or for multiple purposes would ensure that results gained were comparable. The inputs to any model would need to be based on actual current data. If the various forecasts are not based on the same reliable, current data then the forecasts would be of little value.

The examination of the operational models in the USAF showed that the more recent systems like EFMS, the US Army MLRPS and the Dynamic Retention Model, allow the user to interact with the model. This interaction may be the setting up of a desired end structure, or the changing a promotion policy. This "gaming" or what-if capability changed the role of these models from information systems to decision aids. As the objective of this research is to provide decision support for the RAAF, the system must incorporate the ability to interact with the model.

In summary, the RAAF requires three elements in its system--a database, a model base and an interactive link. These are the same as the components provided by a DSS and

formulate the basis for answering the second question of this research:

> *Would a decision support system be an appropriate method of providing the management support required?*

A decision support system provides an appropriate method. A DSS is suitable in areas where the problem is continuously changing, where answers are needed quickly, where data are continuously changing, and where data come from a variety of sources. The RAAF system is one in which answers are required quickly, the data are continually changing and, as explained above, the data comes from a variety of sources. The problem being addressed by this project fits into a number of the categories suitable for DSS application and, therefore, a DSS appears to be an appropriate mechanism for solving it.

Factors Involved in the Process

After making some assumptions, Nixon states that three parameters contribute to the size and shape of the personnel demographic structure of a military organization in a steady-state. These are:

a. the promotion rate,

b. the entry rate, and

c. the separation rate (27:7).

Given these parameters, the future structure of the manpower force can be determined.

There were two assumptions made in the Nixon model. Firstly, that the organization is a closed system in which trained and experienced people come from within the organization. Secondly, lateral movement between categories does not take place. People begin their military employment in a certain category and remain in that category for their entire career. As less than one percent of personnel move between categories and the RAAF is a closed system, the assumptions are essentially correct. However, change in both these areas have been examined as possible methods of solving structural problems (34:183-194).

The addition of an initial inventory to the Nixon model allows these same factors to give forecasts in a dynamic environment and removes the requirement for steady state. These same axioms are used in all of the inventory projection models.

Given only an initial inventory, the entry rate, the promotion rate, and the separation rate, a model can be built and forecasts of the future composition can be produced. However, the parameters of entry, promotion and separation rates are themselves a function of other factors and a model that is to be used as a decision aid needs to incorporate these other factors. For example, the separation rate depends on the category of the officer, the length of time in the service, rank, military personnel policies, and employment opportunities outside the service. Consider Table 1 as a list of the factors that influence the

separation rate. It shows the separation rate factors that are used by the USAF Enlisted Force Management System (8:44).

The number of factors that are included in a model depends on the realism required. The factors that must be captured for a totally realistic model would include the health of the officer's immediate family, the age and schooling level of dependent children, civilian employment opportunities, since all of these factors contribute to the decision process. Whilst an increase in the number of

TABLE 1

Attrition Variables Considered by EFMS

Education
Race
Sex
Date of Enlistment
Age
Marital Status
Number of Dependents
Term of Enlistment
AF Qualifying Test Percentile
Grade
AFSC
Unemployment Rate
Civilian Wage
Military Wage

factors will normally increase the realism of a model, there are factors whose inclusion will not significantly improve the quality of the forecasts. The RAAF system is concerned with aggregate figures at the category level and so the

level of realism appropriate for analyzing individual's decision process, like those presented above, is not required. The inclusion of these factors would not significantly improve the forecasts and hence the data collection costs can not be justified.

A review of many operational models found a number of similar factors are commonly used in modelling manpower. In Appendix B, the factors used by six operational manpower models are presented. The six systems considered are TOPLINE (24), DOPMS (24), OSSM (24), EFMS (8), ROS (26) and MLRPS (19).

From the matrix in Appendix B, factors that occurred more than once have been selected and are presented in Table 2.

The factors in Table 2 were each considered for inclusion in the RAAF model, bearing in mind that the system is to be used by manpower managers at the category level.

Recruitment Rate. The actual number of people recruited into the different categories of the service is the boundary level of concern for RAAF personnel managers. RAAF recruiting officers are responsible below this boundary for such things as quality and number of applicants, inquiry rates, acceptance rates and success rates. The RAAF recruiting area of responsibility is outside the scope of this research. In summary, only the category and the number of people recruited will be included as factors in the recruiting rate for the RAAF model.

TABLE 2

Common Factors Included in Manpower Models

Recruitment Rate:	
	Training Rate(Output of Schools)
	Limits on categories of recruits
Promotion Rate:	
	Entrance Mode (Acad, Direct, ROTC)
	Rank/Grade
	Category/AFSC
	Time in rank
	Years of Service
	Historic Promotion Rates
	Limits on Promotions
	Cohort
	Qualifications
Separation Rate:	
	Rank/Grade
	Category/AFSC
	Aircrew/Non-Aircrew
	Years of service
	Force out points
	Obligation
	Economic conditions
	Minimum retirement age/time
	Reenlistment bonus
Other:	
	Costing of Grades
	Target Strength

Promotion Rates. Officers who have a university degree (either from the military academy, or a civilian institution) can have an advantage over those that do not have a degree. When an officer has a degree, he starts his career one rank higher than officers without one. After this initial head start, there is no discrimination made between officers based on their educational background. If

years of service is being compared with rank, then educational background will be a factor. The higher initial rank will mean they will be promoted earlier than non-degree officers. On the other hand, if years in rank is being compared with promotion rate, then educational background is not a factor. All officers have the same minimum time in rank requirements. Entrance mode is therefore a factor in the RAAF, but only when years of service are being considered.

The different structures of the various categories of officers in the RAAF means that certain categories of officers progress more quickly and to a higher level than others. For example, the Supply officers' structure requires fewer junior officers and so progress in the category is faster than average. On the other hand, the Air Traffic Control (ATC) Officer structure is designed to have a large number of junior officers and few senior officers. This is done because of the role ATC officers perform. Given their required structure, progress to senior levels is very slow. These two examples provide evidence that rank and category does affect the promotion rate.

A number of positions in the RAAF are designated as "ANY" category positions. These positions do not have a designated type of officer who must fill them. The availability of these positions give the RAAF promotion boards some flexibility in the number of promotions they decide to make in any particular year. If one category has

a number of high quality officers available, more can be promoted while promoting less of another category. This flexibility allows them to smooth promotion rates and to maintain a higher quality of promotee. The smoothing of promotion rates results in the historical promotion rate being a factor in determining numbers of promotions rather than the years of service or the time in rank. These factors are significant to an individual's chance of being promoted but are not significant when considering the aggregate promotion rate. By using aggregation, the modelling process is simplified but a level of detail is lost. Part of the lost detail is the attributes of each individual. Factors which affect an individual's promotion chances but do not affect the overall group promotion rate, such as an individual's ranking within the group, will not be significant in the aggregate promotion rate.

Another factor that influences an individual's chance of being promoted is his performance evaluation reports or performance cohort. Cohort is a group ranking based on performance appraisals. Although this factor can influence an individual's chance of being promoted, it is not considered significant in determining the aggregate promotion rate. This is particularly true given the flexibility the promotion board has in the number of promotions of a particular category.

Special skills, qualifications and restrictions all influence an individual's promotion chances but are not

considered to have a significant factor on the aggregate category promotion rate.

In summary, the factors to be included in the promotion rate for the RAAF model are entrance mode (with or without a degree), rank, category, and historical promotion rates.

Separation Rate. Historical data clearly shows that rank and category are significant factors in separation rate. These factors must be included in the model.

A number of military services require that their officers leave the service if they are not promoted within a given time period. This policy is often referred to as an "up or out" policy and it results in a "force-out" point for each rank. This policy is not used in the RAAF and its introduction is not being considered. Therefore, force-out points are not considered a factor in the RAAF separation rate.

Officer aircrew are all pilots, navigators and air electronics officers. Each of these aircrew types is a separate category composed only of aircrew members. Therefore the aircrew/non-aircrew factor is redundant for the RAAF as it is incorporated into the category rates.

Most promotions, courses and postings to operational units in the RAAF carry some kind of obligation to remain in the service for a period of time after the event. In the RAAF this obligation is referred to as Return of Service Obligation (ROSO). The time varies, but as examples, promotion to squadron leader has a 12 month ROSO and

graduation from pilot's course has a 10 year ROSO. The number of officers under ROSO will be a factor in the separation rate.

In the RAAF, reenlistment bounties are always tied to some kind of ROSO. Because of this coupling, there is no need to have reenlistment bounties as a separate factor.

Economic conditions and perceived external employment opportunities, play a part in whether a person decides to separate from the service or not. Unfortunately, Steel and Griffeth have shown, using meta-analysis, that the measures of perceived employment opportunities and turnover are only weakly related (32:846). Considering this, it is not feasible to include the factor in the RAAF model.

The minimum retirement age and years of service (YOS) are both factors that appear to influence the separation rate. A number of studies have shown a reduction in the separation rate of officers in the five years before they reach the minimum YOS required to obtain retirement benefits (26:103). These studies also show an accelerated separation rate after reaching the milestone (presently 20 years for the RAAF). Under a new retirement scheme introduced in 1990, retirement benefits will be tied to age rather than YOS. This should significantly change the separation rate pattern. Both these factors, retirement age and years of service, should be included in the model.

In summary, the factors to be included in the separation rate for the RAAF model are rank, category,

retirement age, YOS, ROSO, and historical separation rates.

Initial Size. From the other factors listed in Table 2, target strength is a clear factor for the RAAF. Costing of the force is done separately to manpower calculations in the RAAF.

Other factors required to initialize the model are rank, category, time in rank, years of service, authorized limits and an overall size limit.

Table 3 summarizes the factors to be included in the RAAF model and provides part of the answer to the third question of this research:

> *What factors are significant and how do they interact in the manpower structure? Can these factors be incorporated into the models?*

The literature has isolated many significant factors, and their incorporation into the model will be discussed in the next two chapters.

Conclusion

The literature review was conducted with the aim of answering three questions--what is the best way to model manpower; would a DSS be appropriate to this project; and what are the significant factors.

The RAAF presently uses a closed personnel system. The closed system combined with the small officer pool, gives management limited flexibility in the short term (less than one year). The aim of this research is to provide a tool

TABLE 3

Factors to be Included in RAAF System

Recruitment Rate:	
	Number Accepted
	Category
Promotion Rate:	
	Entry Method (Degree/Non-degree)
	Rank
	Category
	Historical Promotion Rate
Separation Rate:	
	Rank
	Category
	Years of Service
	Obligation
	Minimum Retirement age/time
Initial Size:	
	Rank
	Category
	Costs of each rank
	Time in rank
	Years of Service
	Authorized limits for category/rank
	Overall limit

that will allow early identification of problem areas before short term dramatic action must be taken. To meet this objective, the system produced should address the medium to long term (one to five years). From the examples given and the literature reviewed, it appears that the inventory projection model based on a Markovian process provides an appropriate modelling solution.

Examination of current operational models reveals a migration to more advanced decision aids. The more recent and advanced systems like EFMS, the US Army MLRPS and the

Dynamic Retention Model allow the user to interact with the model. This interaction may be the setting up of a desired end structure, or the changing a promotion policy. This "gaming" or what-if capability changes the models from information systems to decision aids. As the objective of this research is to provide a decision aid, it too must incorporate an ability to interact with the model. To be an effective tool, the inventory projection model must be based on actual current data and most current historical rates. This necessitates that the RAAF system have access to historical information. If this is not the case the forecasts will be inaccurate and the system will soon lose credibility and be discarded as a decision tool.

In summary, the RAAF system should be based on actual current data, allow interactive user involvement and use an inventory prediction model for forecasting future force structures. These requirements overlay the components of a decision support system and make a DSS an appropriate method.

The future structure of the force can be forecast using present composition, recruitment rate, promotion rate, and separation rate as data. Factors that influence these rates must be included in the system for an accurate decision tool. Examination of factors included in other manpower models provided a list of candidate factors from which the factors relevant to the RAAF were chosen.

III. Methodology

Introduction

The first objective of this research is to develop a system that supports decision making in the area of manpower structure. Chapter II found that an inventory projection model provides an appropriate forecasting model for the future structure of the force and a decision support system is an appropriate environment for supporting management decision making.

The second objective is to determine whether the decision support tool addresses the problem. The problem being the lack of an integrated forecasting system. This chapter will provide the methodology for developing the DSS and validating that it does address the lack of an integrated forecasting system.

Overall Strategy

The DSS will be developed using a staged approach. The stages will include:

a. problem definition and analysis,

b. development of a core DSS,

c. user evaluation and validation,

d. incorporation of user enhancements,

e. development of the more advanced modules, and

f. implementation.

Problem Definition. The majority of this phase has already been covered in the first two chapters. The problem definition was presented in Chapter I and restated in the introduction to this chapter. Problem analysis, presented in Chapter II, covered the selection of the appropriate method. This was found to be a decision support system which comprised an inventory projection model. Chapter II also established the relevant factors that needed to be included in the RAAF system.

Development of a Core DSS. The definition and analysis of the problem will provide a foundation for development of a core system. A core system is a subset of the full system. It will contain all the essential modules to allow the system to be evaluated but will not have some of the more advanced features. The system will be operational although not all options will be available. After evaluation and verification of the core system, a full system will be developed. The advantages of this approach are:

a. it allows user evaluation and feedback on the DSS earlier in the development,

b. it allows user validation of the DSS in addition to the developer's verification and validation before the system is completed,

c. it provides an operational system in the hands of the user in a shorter period of time,

d. it encourages user acceptance of the system

through involvement in the development, and

e. it provides a higher profile for the system and so gathers management support for the project.

A core system will be developed using modules linked to a central modelling component. The advanced modules will be added to the system after the user evaluation is completed. The development of the modules is discussed in more detail in the next section.

User evaluation. The user evaluation and feedback will help ensure that the second objective of this research, addressing the lack of an integrated tool, is done. A copy of the core system will be provided to three organizations concerned with RAAF manpower structure--the Directorate of Manpower Planning and Control (DMPC-AF), the Directorate of Personnel - Officers (DPO-AF) and the office responsible for officer career and posting management policy (POPLANS). After a period of evaluation, these areas will be asked to comment on the operation of the DSS, on problems found with the DSS, enhancements that can be made and how effectively it supports decision making.

Incorporation of user enhancements. During this phase changes and enhancements from the user evaluation will be incorporated into the model. The responses received from the users will be tabulated and compared. Where there is consensus that a change is required, the change will be checked for validity and incorporated into the DSS. If a change is suggested by only one or two areas then its

inclusion will depend on a weight factor. The higher weight will be applied to enhancements suggested by users whose expertise lies in that area.

The use of modules within the DSS will allow changes to be made in one section of the system without affecting the other sections. This will allow the enhancements to be included without having to redo the complete verification of the system. Only the module to which a change has been made will have to be verified.

Validation of the DSS. Each module of the DSS will be verified and validated as it is constructed. In addition, an overall DSS verification and validation will be completed. Each of these is discussed in a following section.

Development of the more advanced modules. Along with the changes and enhancements required to the core DSS required by the users will be the development of the more advanced modules. These modules include a module to extract the relevant current data from the CATSIT database and update the DSS database; modules to allow more detailed control of the number of promotions and separation rates; a module to allow a percentage of a category to be under an obligation to stay in the service (ROSO); a module to allow policy variables such as time in rank to be evaluated; and a module to allow the effects of retirement time and age to be evaluated. These modules will be developed and incorporated in parallel with the user generated changes. The same

verification and validation methods applied to the core modules will be used for the advanced and changed modules.

Implementation. The final implementation will be done after all other phases are complete. Providing that the core system is validated as an effective tool, a production system will be developed based on the core DSS with the advanced modules added and the enhancements and changes incorporated. This production system will be verified using the same techniques as used for the core system. The production DSS will be provided to the areas concerned with manpower management. The package will include documentation outlining the procedures for updating the database, making changes to the system, trouble shooting and contact numbers for help. The author has been assigned to one of the user areas and will remain the central point of contact and instruction on the use of DSS for the foreseeable future.

Developing the DSS

The DSS will consist of three components--a database, a model base and a user dialogue system. The relationship and integration of these components can be seen by looking at the overall process required by the RAAF:

a. entering different scenarios;

b. accessing a database of the present structure or aggregate historical data;

c. generating forecasts, using the data retrieved from the database and the scenario entered by the

user; and

d. presenting the results in a suitable form.

Each of these tasks must be performed by or done under the control of the DSS. Each of the above tasks is discussed in the following paragraphs.

Scenario Entry. Davis suggests that there are three types of scenario changes that the manager may wish to evaluate:

a. resource changes (for example, a change in the number of staff positions at a particular level);

b. internal policy changes (for example, a change in the promotion policy to allow people to be eligible for promotion after three years instead of five years); and

c. external factors (for example, an increase in the tourism industry may result in an increase in the demand for pilots by the commercial airlines--leading to higher separation rates than expected). (14:175-176)

In general, these scenario changes are referred to as *what-if* scenarios. We need to modify the parameters that influence the model to see the results of these *what-if* scenarios. Resource and internal policy changes will need to be directly input to the model. External factors will be input indirectly by considering the parameters affected by external change and changing those parameters.

There are four parameters that are required to produce a forecast from the inventory projection model used in this DSS. These parameters are the present force composition (initial size), the separation rate, the promotion rate and the recruitment rate. While these parameters are the only requirements for forecasts, the factors that influence these parameters are required if the *what-if* scenarios are to be addressed. A list of the significant factors considered by other researchers was examined in Chapter II. This list was evaluated against RAAF requirements and a list of RAAF factors emerged. Table 4 repeats the factors that will be included in the RAAF model and are required to provide decision support.

The different scenarios require that the user is able to access the different factors, view the historic values and then enter his own scenario estimate. The user interface of the DSS should lead the user through this entry process by highlighting problems, ensure only valid entries are input and anticipate the next action. For example, options should be presented to the user listing possible changes. Once a selection is made, the entry should be checked and, if correct, an option given to model the scenario and view the results.

The intended users of this DSS have computers on their desk and can be considered experienced computer users. As managers, they are frequent users of word processors and spreadsheets. Most of these commercial packages are of a

TABLE 4

Summary of Factors for Inclusion in RAAF System

Recruitment Rate:	Number Accepted Category
Promotion Rate:	Entry Method (Degree/Non-degree) Rank Category Historical Promotion Rate
Separation Rate:	Rank Category Years of Service Obligation Minimum Retirement age/time
Initial Size:	Rank Category Costs of each rank Time in rank Years of Service Authorized limits for category/rank Overall limit

high quality, robust and user friendly. Quality refers a lack of "bugs" in the program and behavior that is predictable and reliable at all times. Robustness refers to a package's ability to handle errors and other unusual situations. Most modern packages are very "fault tolerant". User friendliness implies that the syste should use color, be menu driven, be compatible with a mouse, and make good use of graphics.

If the DSS is to be accepted and used, it must have the same characteristics as those of the commercial packages

with which the managers are familiar. In addition, it must have the characteristics of a DSS. The system must have a model base, a database and an interactive user dialogue system. Given this list of requirements, a spreadsheet package was chosen as the development environment. The package chosen was Quattro Pro® as it was capable of performing the tasks required of the DSS and it was well known to the developer. The factors that influenced the selection of Quattro Pro® (QPRO) were:

a. the QPRO package is readily available,

b. QPRO runs on all versions of the IBM PC and has no special hardware requirements,

c. it has the database, modelling and graphics capabilities required,

d. QPRO has a similar layout and operation to most other spreadsheets and so is quickly mastered,

e. QPRO has a powerful programming language which is transportable to other spreadsheet programs,

f. QPRO can be easily programmed to provide a very friendly user interface utilizing menus and a mouse,

g. QPRO can produce high quality graphics for output on screen or on paper, and

h. all components of the spreadsheet are well integrated and robust.

The minimum skills required to operate this application will be the ability to load Quattro Pro® and then retrieve a

file. While most managers will have at least these skills, the user guide will also cover these tasks. The remainder of the DSS will be menu driven with appropriate messages instructing the user what action is required.

Database Access. Data on the present force strength, data on present personnel, historical data on recruiting rates, promotion rates, separation rates and policy data (for example, minimum age for retirement) need to be held in the DSS database. All of this data is currently available on the Air Force Personnel and Establishment Management System (AFPEMS) HP3000 mini-computer. However, the DSS would need to retrieve it from a number of databases on AFPEMS. This makes direct access to the data difficult. Fortunately, the POMANPLANS section of DPO-AF already extracts present force composition data from the HP3000 databases into a Microsoft Excel® spreadsheet. POMANPLANS combine their AFPEMS extracted data with historical data, held in spreadsheet form, to produce the quarterly CATSIT report and for POMANPLANS recruiting forecasts, as discussed in Chapter II. The historical data held on the POMANPLANS computer include average numbers of promotions and numbers of separations by category for the last 10 years. Interfacing with this PC computer is a considerably easier task and more convenient than extracting data from AFPEMS. As the POMANPLANS computer is electronically linked to the master records and the link has been validated, the data will have the same integrity as the master from which it was

taken. The data from the POMANPLANS spreadsheets will be combined with other manually entered data to provide the basis of this DSS.

The extraction of the quarterly data from the CATSIT database will be done by the DSS. To ensure data integrity, the data required by the DSS will be extracted and copied to the DSS database under computer control. On a periodic basis, new data will be extracted from POMANPLANS computer and combined with historical data held in the DSS database. This updating process will be automated to ensure data validity and help ensure that the DSS meets its objectives, namely, that the system use current information, be reliable and provide timely information.

Modelling. The model used for forecasting will be an analytical inventory projection model. Models of this type use the notion idea that the number of people that make up the structure of an organization are the inventory of that service. The inventory enters the system, progresses through it, and leaves at some time in the future. In the case of this DSS, the rate of input to the system is the recruitment rate, the rate of movement through the system is the promotion rate, and the rate of output is the separation rate. This model can be expressed as: the number of people in the system of a particular rank and category is equal to the number of people of that kind in the previous year plus those who have been promoted into that rank, less those that have been promoted out and the percentage that separated.

This can be expressed by the formula:

$$N_{r,t+1} = N_{r,t} + P_{r-1,t} - P_{r,t} - (N_{r,t} * S_{r,t}) \quad \textbf{(2)}$$

where

$P_{r,t}$ is the number of promotions from rank r in year t

$N_{r,t}$ is the number of officers at rank r in year t

$S_{r,t}$ is the rate of separation from rank r in year t

This equation provides the foundation for the inventory projection model. The separation rate is expressed as a percentage of the present force ($S_{r,t}$) as this is the method most commonly used by manpower managers. The other values are positive integer values representing the number of people promoted or presently at that rank. The number promoted into a category at the lowest level is the number of recruits into that category.

The model makes two assumptions. Firstly, there is only one category of officer and, secondly, that no lateral movement of officers takes place. If these assumptions do not hold true, then the number of people of a given rank and category will be affected by lateral movement into that category from other categories and out of that category into the others. The equation becomes:

$$N_{c,r,t+1} = N_{c,r,t} + P_{c,r-1,t} - P_{c,r,t} - (N_{c,r,t} * S_{c,r,t}) + \sum_{c=1}^{n} L_{c,0,r,t} - \sum_{c=1}^{n} L_{0,c,r,t} \quad \textbf{(3)}$$

where

$P_{c,r,t}$ is the number of promotions of category c from rank r in year t

$N_{c,r,t}$ is the number of officers of category c at rank r in year t

$L_{b,c,r,t}$ is the number of lateral recruits from category b into category c at rank r in year t.

$S_{c,r,t}$ is the rate of separation from category c of rank r in year t

n is the number of categories.

The equation to be used in the core model considers only one category at a time but it does allow for lateral movement. As personnel managers normally are responsible for one category this should not restrict the use of the system. An overall category will be included to allow for manpower management decisions. In general, most of the scenarios required by management would either concentrate on just one category at a time or the overall force. The combination of categories could be incorporated at a later stage, if required by the users.

The core model allows management to select a particular category and rank and produce forecasts using historical data. The production of a forecast would require the user to select a category and rank. Upon selection, current policy and forecasts based on historical information are produced and can be viewed. To perform *what-if* calculations, the user can change the following from their default value:

a. the separation rate,

b. the number of promotions per year,

c. the number of recruits per year, or

d. the lateral movement into that category per year.

After making these changes the forecasts can again be viewed and compared.

After validation of the core system, the more advanced modules will be added to the system. These modules will accommodate additional factors, such as, entry method (with or without a degree), percentage of a category under an obligation to stay in the service (ROSO) and a movable retirement barrier. Each of these factors will be in a separate module of the DSS. Each will perform accept user entries, do calculations on the data and then substitute its calculated value for the database default value.

Result Presentation. To ensure the system developed in this research is accepted and used, the DSS must provide output that is useful and easily understood by the user. The DSS will allow the manager to select whether output is required by year, by rank or both and then select whether he wants a numerical or a graphical output of the results. The primary output will be to provide the output in a color graphical form, with numerical output as the secondary option. This visual format has a high impact, is quicker and easier to digest. The outputs will show comparisons of the following: present strength versus established positions, projected rank strength versus time, category

structure versus time, projected structure using the historical values versus structure under the user scenario. Printouts of this information would be available, again in either graphical or numerical form.

The evaluation phase of the development process will be used to ascertain how well these graphs and tables meet the requirements of management and whether other forms of output are required. Enhancements and changes that come from the evaluation will be included in the final system.

Verifying the Model

Verification is the process of checking that the system does its tasks of retrieving, modelling and displaying correctly. During the building of the system modules, testing and documenting will be used to verify that the modules are performing their tasks correctly. The process will include documenting the code, ensuring that the input-output transformations are correct and building error trap routines. The input-output transformation will be done by using both logical deduction and comparison of the model with hand-calculated results. Logical deduction will ensure that the DSS results are intuitively correct. For example, if the separation rate for a particular rank is increased by 10%, then logically or intuitively the number of people in that rank in the next year should decrease from its initial value, all other things being equal. The intuitive checks will ensure that data do (1) change, (2) change in the

correct direction, and (3) change by the approximately correct amount. The second kind of the input-output verification will be hand calculations. The modules will be tested quantitatively by comparing model results with manual calculations using the model formula. The final check to be performed on each module will be to try and induce an error in the module. This will be done by entering strange keyboard combinations. The system should trap and handle the error. Each module of the DSS will be built using this method and extensive reuse of error trapping routines will be used to ensure consistency.

A final verification of the entire system will be an overall input-output check. The test will be to enter a test category into the DSS database and compare the DSS forecasts for this category with hand calculated results. This is the same type of test that will be done for each of the modules but this time the overall system will be tested.

Validating the Model

The construction of the DSS is only one component of providing a usable system. Validation is another major component. Validation is the process of ensuring the right system has been developed. Bratley describes validation as testing that the model is a sufficiently close approximation to reality for its intended application (7:8). As no single technique is adequate to validate a model, a number of techniques will be used during the construction and after

completion of the system.

The first stage of validation will seek face validity of the internal structure. Face validity will be established by checking that the way the system model is formulated is in agreement with other models. This will be done by comparing the model with other research work and theory. Examples provided in (27) and (24) allow this validity to be established. The next stage is called input-output transformation validation. This entails comparing the transformations generated by the model with those generated in the real world and the output of other models. The first test is similar to the overall verification test but it will take its initial values from actual 1984 data and use actual numbers of promotions, separation rates, and recruits. The forecasts will be checked that against actual data from 1985-1988. By checking the data against actual data, verification and validation is being performed. The second test will involve entering different values for input factors and comparing the results obtained using the DSS with an established model, namely, the POMANPLANS model. This technique was successfully used by Argüden to compare retention models (3:38-40).

Statistical tests will be performed to confirm that the DSS output is from the same population. If significant differences exist between the actual and the forecast data, a Wilcoxon Rank Sum test will be used to confirm that they come from the same population. The Rank Sum test checks the

hypothesis that the probability distributions associated with two populations are equivalent.

The final stage of validation is user testing. The aim of this check is to ensure that the DSS does meet the requirements of the users. The format of this test will be to survey the users on how effectively the system supports their decision making. Due to the small number of users a statistical test cannot be applied, however, the small population will allow all user views to be hear. The survey technique to be used, given the small population, is structured open-ended questions.

Decisions on whether to include an enhancement or make a change to the DSS will be based on the following criteria:

a. If there is consensus on an item and it is feasible then it will be implemented.

b. If there is disagreement on an item then all views will have a weight applied to them. Using the weighted responses, the researcher will make a decision on whether to implement the item. The weight will be based on:

   i. the importance of that feature to the user,

   ii. the effect the feature will have on other users,

   iii. the frequency with which the feature will be used, and

   iv. the relationship between the area of expertise of the user and the feature.

The survey technique should also allow the researcher to ascertain an overall impression of the extent to which the DSS is meeting the users needs.

Each question on the survey was validated. This was done by ensuring that the response to each question would contribute to meeting the objectives or answering the research questions. If it did not then it was removed from the survey. In addition, the survey questions were reviewed by the thesis advisor. A list of the validated survey questions is in Appendix C.

Meeting the Research Objectives

The DSS system which is built using the development methodology, verification and validation checks above will meet the objectives of this research. It will have answered the research questions, and achieved the two objectives of the research--developing a system and then determining that it addresses the management problem.

IV. Analysis and Findings

Introduction

In chapter III the methodology for meeting the objectives of this research was presented. The methodology included the development of a core system and then evaluation of this system by users. The user testing would validate that the system was providing a solution to the problem and it would also give the users an opportunity to suggest changes or enhancements to the system. These changes would then be incorporated into the final production system. By using this method, only a system that met the objectives would be delivered.

In this chapter the development of the system is detailed and the responses received from the user evaluation are analyzed and discussed.

DSS Development

Following the method outlined in Chapter III, the development was done using a modular approach. There were a number of advantages to this approach. Firstly, the modular design permitted user evaluation before all sections of the system were fully functional. This was considered important as user evaluation was a critical step in the overall strategy of the project. Early feedback from the users would ensure that the system being developed was the right

one. The feedback would validate the model. Despite the need for early feedback, it was important that the model gave a good impression of the final product. The user evaluation would help the system to gain acceptance if the evaluation was favorable but it would build resistance if the system performed poorly. The system, therefore, had to be as "bug-free" as possible, have a good user interface, and be close enough to complete to allow the final direction and quality to be seen. The modular approach allowed this early evaluation to take place.

Another factor in user acceptance of a system is confidence in the results. The modular approach allowed verification and validation of each different function to be accomplished easily and without interfering with the other functions.

The core system contained the following sections:

a. a model module,

b. a database module,

c. a database interface/category selection module,

d. a reset module,

e. a save module,

f. a graph module,

g. a print module, and

h. a parameter modification module, which included sub-modules for handling promotion, recruitment, separation and lateral movement.

The modules to be developed as part of the advanced system were:

a. an on-line database update,

b. an advanced promotion module, and

c. an advanced separation module.

The modular approach combined well with the menu structure designed for the DSS. The modules very closely aligned with the different menus, and so the modules were developed, verified and validated as the new pages of the menu tree were built. The overall menu is shown in Figure 4.

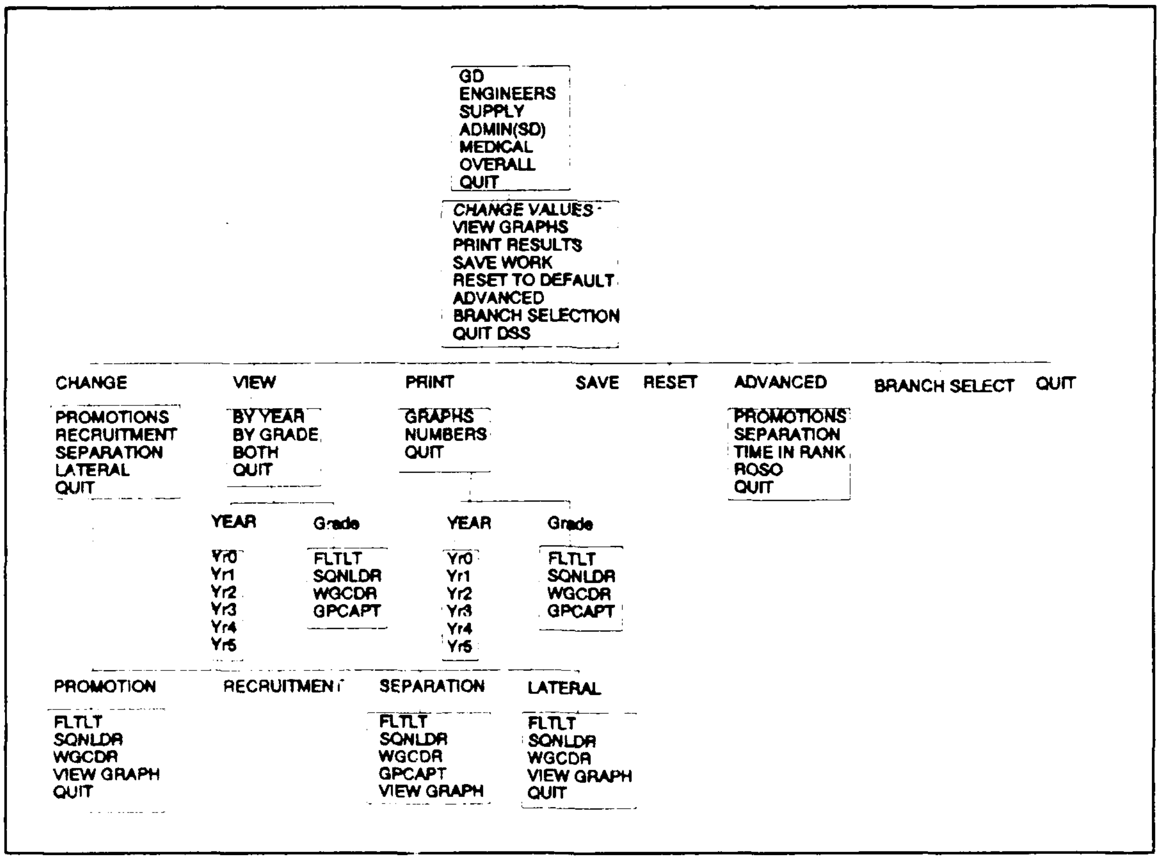

Figure 4. Menu Structure Used in the RAAF Manpower DSS

In conjunction with the menu tree, and before any modules were built, a layout for the spreadsheet was planned. This plan is shown in Figure 5. The idea behind this plan was to make allowance for more code to be inserted in the future without disrupting the rest of the sheet. The use of only the top and left sides of the spreadsheet allowed for this later expansion.

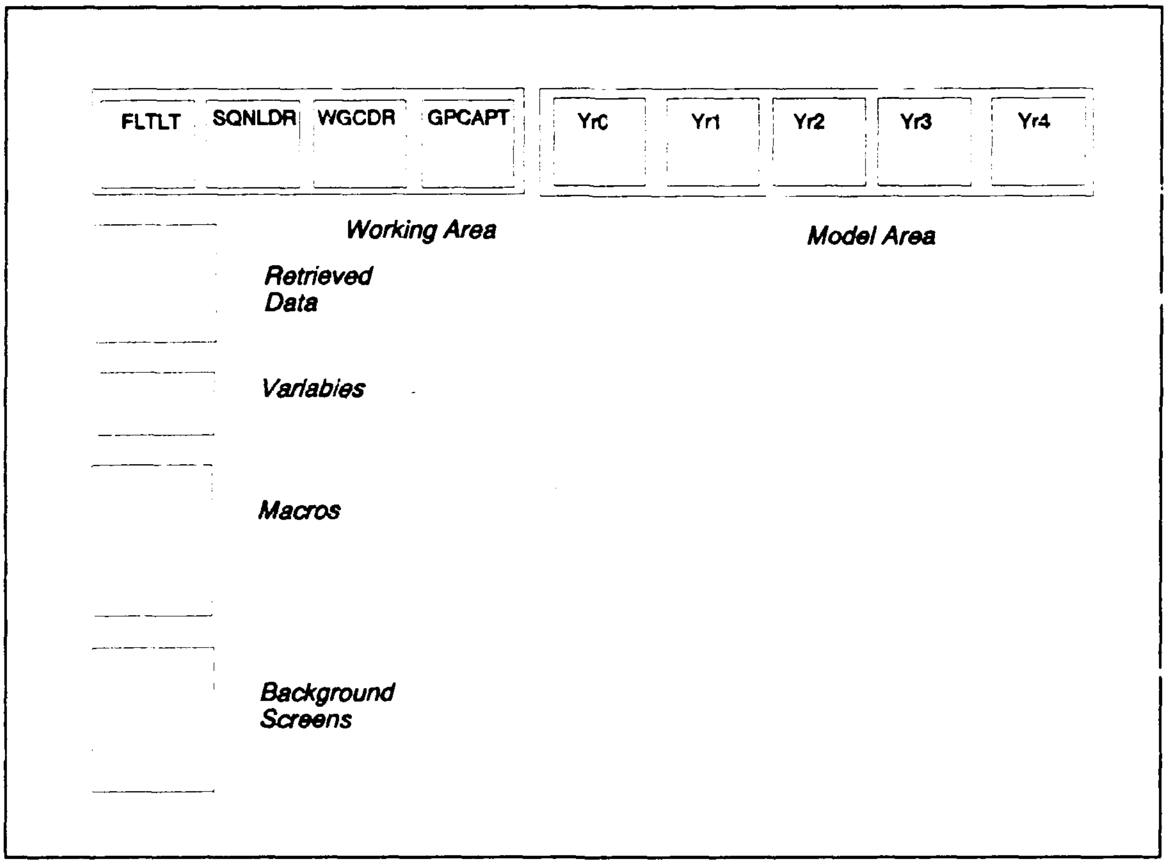

Figure 5. Layout of the DSS in the Spreadsheet

A discussion of the development of the individual modules is given in the following paragraphs.

The Model Module. As discussed in Chapter III, the system is required to do forecasts in the medium term

future. With this in mind, the DSS was built to do forecasts up to five years in advance. The data for year zero, the current period, is read in from a database. Forecasts for the future periods are predicted using this initial period, historical or scenario rates of promotion, separation numbers and recruitment numbers. The data fields read into the DSS are category, rank, present number, authorized positions for that rank, historical promotion rates, historical separation rates, historical recruitment rates, and average time in rank. Using this data, and a variation of the model developed in Chapter III, forecasts up to five years in advance are made. The variation made to the model was to allow internal lateral movement of officers. In Chapter II, it was noted that lateral movement in the RAAF was presently almost zero. However, it was also noted that lateral movement had been considered as a method of solving structural problems on a number of occasions. Given this background, it seemed sensible to make allowance for this movement when developing the model. The lateral movement default value for all categories of officers will be zero. The equation used in the DSS is:

$$N_{r,t+1} = N_{r,t} + P_{r-1,t} - P_{r,t} - (N_{r,t} * S_{r,t}) + L_{r,t} \tag{4}$$

where

$P_{r,t}$ is the number of promotions from rank r in year t

$N_{r,t}$ is the number of officers at rank r in year t

$L_{r,t}$ is the number of lateral recruits into rank r from

all other categories in year t.

$S_{r,t}$ is the rate of separation for rank r in year t

The testing of this module included documenting the code, ensuring that the input-output transformations were correct and that errors were trapped. The input-output transformation was done by both logical deduction and comparison of the model with hand-calculated results. The hand calculated values presented in Table 5 were entered into the model module of the DSS and results compared. The first three tested the individual factors to verify that each functioned correctly. The final two tests checked that the individual components did not react with each other and that the overall results were correct. The test data and the DSS results are shown in Table 5.

The DSS results were identical to the hand calculated results except in tests four and five. In test four, the DSS produced values of 857, 796, 742 and 691 for years 2 through 5. The hand calculations gave values of 858, 797, 742 and 693. Similar small errors can be seen in test five. These errors can be attributed to the rounding which was done in the model but was not performed in the hand calculations. The model rounds the separation rate down to the nearest person (as a fraction of a person cannot separate). If this correction is applied to the hand calculations, and then this rounded value for each Yr(t) is transferred into the corresponding Yr(t+1) calculation, identical results for the DSS and the test data are

TABLE 5

Verification of Individual Modules in the DSS

Test 1 - Separation Rate

	Yr(t)	SepRate	Sepns	P-In	P-Out	DSS(t)	Err
Yr0	1000	10%	100	0	0	1000	0
Yr1	900	10%	90	0	0	900	0
Yr2	810	10%	81	0	0	810	0
Yr3	729	10%	73	0	0	729	0
Yr4	656	10%	66	0	0	656	0
Yr5	590	10%	59	0	0	590	0

Test 2 - Promotions In

	Yr(t)	SepRate	Sepns	P-In	P-Out	DSS(t)	Err
Yr0	1000	0%	0	100	0	1000	0
Yr1	1100	0%	0	100	0	1100	0
Yr2	1200	0%	0	100	0	1200	0
Yr3	1300	0%	0	100	0	1300	0
Yr4	1400	0%	0	100	0	1400	0
Yr5	1500	0%	0	100	0	1500	0

Test 3 - Promotions Out

	Yr(t)	SepRate	Sepns	P-In	P-Out	DSS(t)	Err
Yr0	1000	0%	0	0	100	1000	0
Yr1	900	0%	0	0	100	900	0
Yr2	800	0%	0	0	100	800	0
Yr3	700	0%	0	0	100	700	0
Yr4	600	0%	0	0	100	600	0
Yr5	500	0%	0	0	100	500	0

Test 4 - Combination

	Yr(t)	SepRate	Sepns	P-In	P-Out	DSS(t)	Err
Yr0	1000	10%	100	100	75	1000	0
Yr1	925	10%	93	100	75	925	0
Yr2	858	10%	86	100	75	857	1
Yr3	797	10%	80	100	75	796	1
Yr4	742	10%	74	100	75	741	1
Yr5	693	10%	69	100	75	691	2

Test 5 - Varying Combinations

	Yr(t)	SepRate	Sepns	P-In	P-Out	DSS(t)	Err
Yr0	1000	10%	100	0	50	1000	0
Yr1	850	9%	77	10	40	850	0
Yr2	744	8%	59	20	30	743	1
Yr3	674	7%	47	30	20	673	1
Yr4	637	6%	38	40	10	635	2
Yr5	629	5%	31	50	0	626	3

obtained.

The final check done on the DSS model module was to try

and induce an error. The aim was to ensure that the system caught and handled the error. One flaw found in the model was that a negative number of people could occur in the rank of a category. This situation presented a very dramatic image on the output graphics. The values required to create the situation were so unrealistic, however, that it was decided to allow the condition to remain in the DSS. It is not expected to effect the performance of the system.

The Database Module. The database module within the DSS contains the data on the category under consideration. As data is loaded into this database module (by the database interface module which will be discussed next), the data is loaded into all of the applicable working areas. The actual database is not overwritten as rates are changed, but rather only the working area values are changed. The database is only changed by loading a new category. The fields held are the same as mentioned above.

In addition to the database contained in the DSS, there is a separate spreadsheet which contains historical data on all of the categories. This external database is only updated by the POMANPLANS extracted data, on a quarterly basis. The database within the DSS extracts data on the required category from this database.

The validity of the data held in these databases is as good as the POMANPLANS databases from which it was extracted. The researcher assumes the POMANPLANS has valid data.

The Database Interface/Category Selection Module. This module allows the user to select from a menu the category of officer for analysis. Upon selection, the data on this category is loaded from the external database into the DSS database, and all values for the future years are reset to the default values.

This module was verified by taking a number of test categories and loading them into the DSS and ensuring that the data was loaded accurately. No errors were detected. Given that the selection of a category is done from a menu, is fully automated, and that the name of the category loaded from the database is displayed on all reports, the possibility of selecting the wrong category is considered very low. Integrity of the results is therefore considered high.

The Reset Module. The reset module is run after a new category is loaded or by the user selecting it from the menu. The reset module is designed to ensure that all values in the working storage area are initially given the correct value. As the user enters his own scenario, he will overwrite these values. The reset module operates by copying the appropriate formulae into each cell in the working storage area and then copying the current DSS database into the working area.

This module was verified by changing large numbers of values in the DSS and then checking that all values returned

to their original values after reset was selected. The module operated correctly on all tests.

<u>The Save Module</u>. This module allows the user to save the spreadsheet in its present form. The user is prompted for a document name and then the file is stored under this name. As the maximum length name that can be used is eight characters, a function was built in to automatically truncate names greater than eight characters. A number of trials were conducted using this module to verify that it worked correctly. The tests included saving the data under different names, using names longer than eight characters and using the same name. On each occasion the data was saved correctly.

<u>The Graph Module</u>. The Graph module presents data in one of three ways. Each of the three is a plot of strength versus the ideal, but it can be seen by grade, by year or both. An example of a "By Year" graph is shown in Figure 6. Note that the graph includes both bar diagrams and numerical values of forecast strength to assist decision making. All graphs include a list of options for switching between years or grades.

The graph modules were verified using the same test data as the model module. The graphs were checked for correct length and numerical value. No errors were found.

<u>The Print Module</u>. The Print module allows the user to print out the graphs discussed above. In addition to the graphs, the actual numerical tables can be printed. These

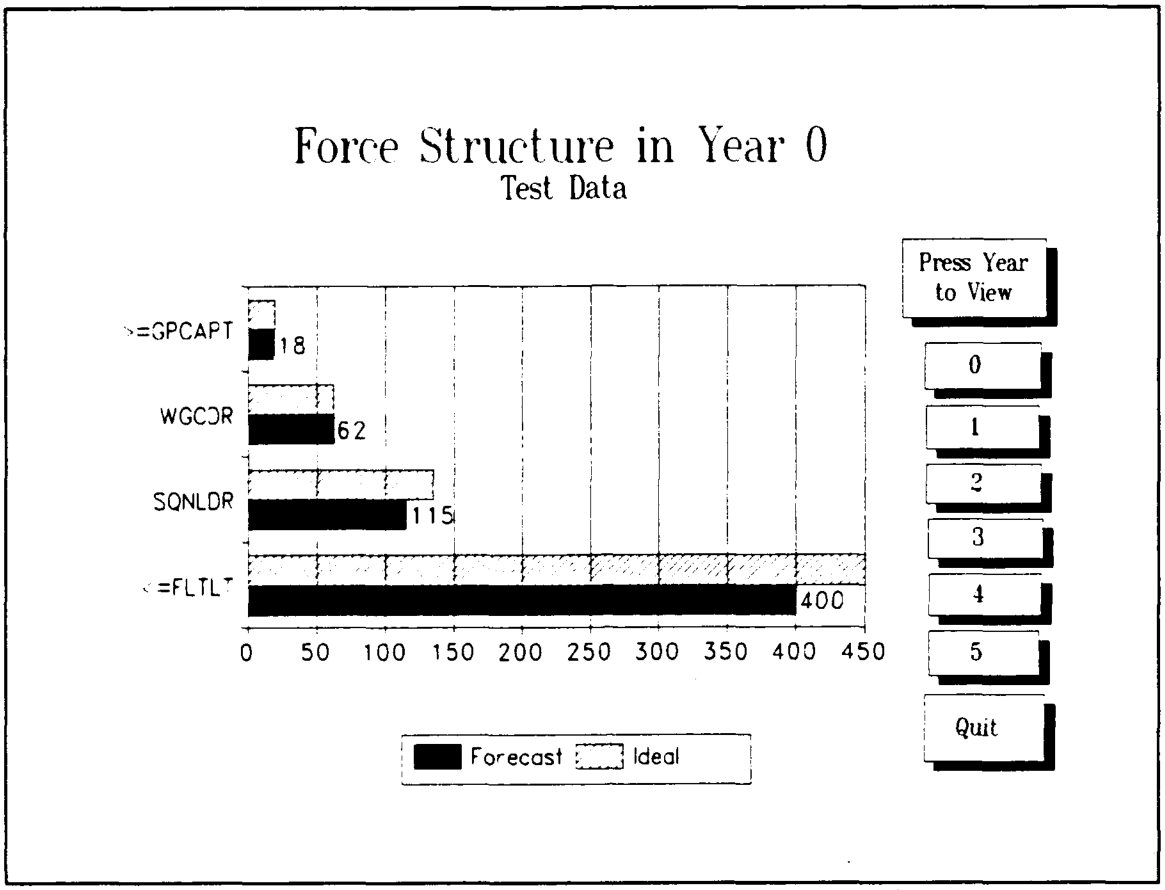

Figure 6. An Example of a "By Year" Display

tasks are done under menu control with selections available, in a similar fashion to the graphic displays.

This module was verified by using the test data again and checking the results. No errors were encountered.

The Parameter Modification Module. The Parameter modification module is the major component of the *what-if* capability of the DSS. It contains sub-modules to allow modification of separation rates, the number of recruits and the number of promotions. The factors can be applied to all areas unless their application does not make sense. For example, (1) the factor affecting the number of recruits is

only usable on the lowest rank, and (2) the factor affecting promotions cannot be applied to the highest rank in each category.

The parameters are entered under menu control. A user entered value will override the default value already stored in the DSS working area. The values are placed in the Year Zero working space and the DSS automatically copies them into the future year forecasts. The input screen is designed to allow visual verification to the user that the values have been updated.

The operation of this module was tested by visually checking that the data had been copied into future years, and that the new values were used in the calculations. Both of these checks were satisfactory.

<u>The On-line Database Update Module</u>. The On-line Database Update module is the first of the advanced modules and has not been developed as yet. The module will need to be able to access the data presently in a Microsoft Excel® spreadsheet. Quattro Pro® cannot directly read MS Excel® spreadsheets. However, both packages can read and write Lotus 1-2-3® spreadsheets. Therefore, one way of transferring the data appears to be run a macro on MS Excel® to export the data and then a macro on Quattro Pro® to import it. Both of these tasks could be performed under a "batch file" and therefore not need user input. The batch file could in turn be automatically run in Quattro Pro®. The final result for the user should be a menu selection in

the DSS and then a delay as the batch files run. No other user input should be required until the update process is complete.

The On-line Database Update module will be completed when the researcher returns to Australia. The naming conventions of the spreadsheet areas and other intricacies require extensive liaison between the researcher and the manager of the POMANPLANS system. This cannot be done until the researcher returns to Australia.

Verification of this module will be done by loading test data into the POMANPLANS system and ensuring that it is transferred to the DSS without corruption and without user assistance.

<u>The Advanced Promotion and Advanced Separation Modules</u>. The Advanced Promotion and Advanced Separation modules require that the relationship between factors such as years of service or time in rank be established. In an attempt to do this, a large amount of historical data was evaluated with the hope of establishing one or more standard relationships. Data from the POMANPLANS databases, several manpower reports, and manually extracted data were collected for analysis. The data were all based on years in rank rather than years of service. Historically, this is the way officer data has been recorded. Analysis was conducted on the seniority distributions (that is, time in rank), average promotion distributions and average separation data for selected ranks from several categories to try and establish

the relationships. The categories and ranks were selected randomly. Analysis quickly showed that the distributions of seniority, promotions and separations were markedly different for each rank and each category.

As an example, consider Figures 7 and 8. These figures show the present seniority distribution of two categories, NAV and ADMIN, along with ten year average separation and promotion rates for squadron leaders in those categories. The seniority graph for each shows the spread of experience for the squadron leader rank. The year bars represent the percentage of the category within that seniority range. The

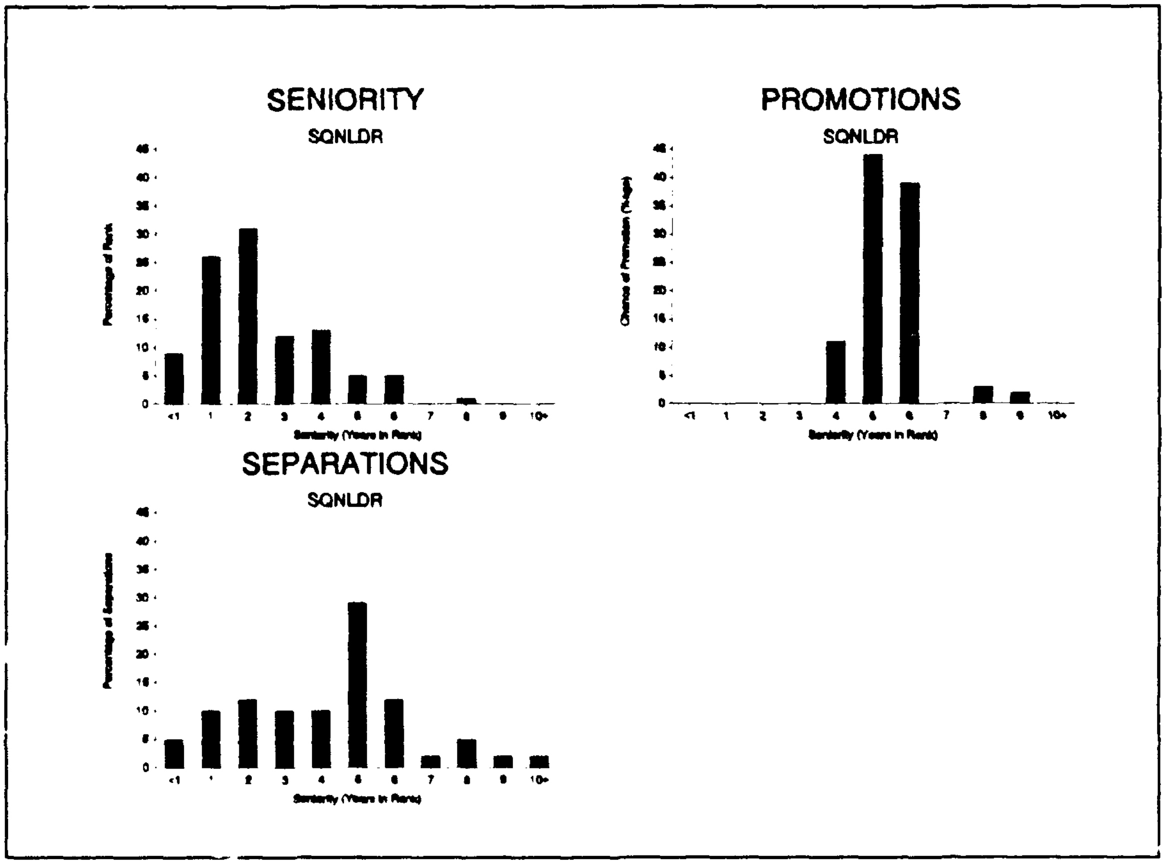

Figure 7. Present Seniority, Average Separation and Average Promotion Distributions of the NAV Category

shape of these curves are markedly different. The promotion distribution graph and the separation distribution for each category are also quite dissimilar. Other categories and ranks also had quite different distributions.

Given the differences between the distributions, the best way of providing decision support to managers appears to be to provide the actual distribution of the category to the DSS and then use that distribution for the forecasts. The value of the actual distribution can be seen by again looking at Figure 7. Consider, a scenario in which a change

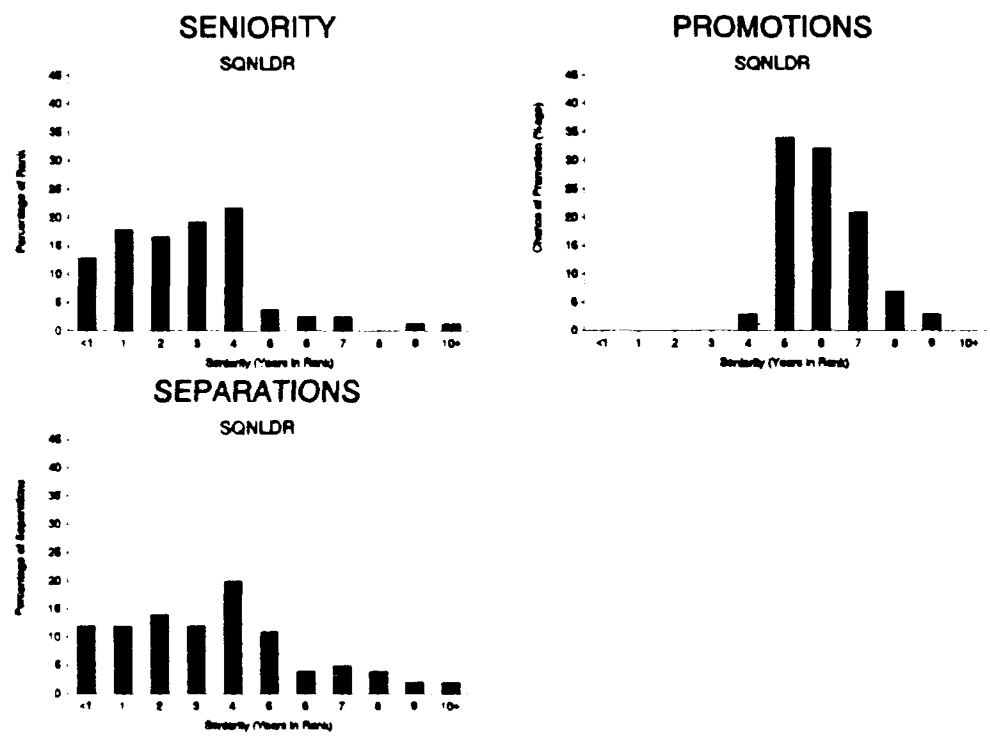

Figure 8. Present Seniority, Average Separation and Average Promotion Distributions of the ADMIN Category

in policy to lower the seniority requirement is being considered. The level is presently five years (the promotions shown in the four year bar were early in the 10 year averaging period when the limit was four years). If the limit is lowered to four years, only a few officers (about 10%) would be added in the next two years. However, in the following two years nearly 55% of the category would be eligible (years 3 and 4) with the number then reducing to less than 10%. If management desires a fairly even number of candidates each year, from the NAV category, it appears that the promotion policy needs to be reviewed annually. The DSS could be used in the selection of the promotion point to ensure that a given percentage of officers are eligible for promotion.

Figure 8 shows a very different distribution of seniority and a different promotion distribution. A quite different policy may be required for this category.

Similar treatment can be applied to the separation distributions and to all the other categories. For this reason, the best method of applying the Years in Rank factor appears to be to present a graph of the current distribution, the average promotion distribution and the average separation distribution and let the user decide the best way to apply the information.

To provide this data, fields containing the distributions need to be added to the database, and graphs need to be provided. The fields that need to be added are

(1) eleven fields for the present seniority, one for each of zero through nine year brackets plus a ten and above field; (2) eleven fields for the average number of promotions also broken into years zero through nine and ten and above; and (3) eleven fields for the historical probability of separations again divided into years zero through nine and ten and above. All of this data can be automatically extracted from the POMANPLANS database. The type of graphs that need to be provided should be similar to those presented in Figures 7 and 8, that is, a plot of chance versus years in rank.

Although the data is available on POMANPLANS database, more work needs to be done before the module can be completed. The work includes liaising with POMANPLANS on the names to be allocated to the various data fields required and other computer linking requirements. It is not possible to do this until the researcher returns to Australia and has direct access to the POMANPLANS database.

The verification of this module would be done by comparing the graphs obtained on the DSS after transmission with the originals on the master system. The validation is more complex as it depends on how the data is integrated into the system and how managers use the data. More research is required in this area.

The problems associated with the distributions has repercussions for another factor, Return of Service Obligation (ROSO). A module that allowed the number of

people in a category at a particular rank who were under a ROSO could be developed for the DSS at this time. However, if the actual distribution of personnel were available a better estimate of its effect may be possible. For example, remembering that all officers are under ROSO for their first year after a promotion; if an actual distribution showed a predominance of officers to be in their first year of seniority then reduced separations could be expected. Using the data in Figure 7 again, two years ago approximately 30% of SQNLDR NAVs would not have been able to separate because they were under promotion ROSO. Since the average percentage of officers with this seniority is approximately 15%, there should have been a decrease in the overall SQNLDR NAV separation rate for that year.

More data on ROSO needs to be collected, more research needs to be done, and the inclusion of actual distributions into the DSS must be done before any relationship can be incorporated into the DSS.

Overall DSS Verification

The modules up to the parameter module were included in the core DSS which was used to validate the model and allow users to become familiar with the system. To ensure that the system operated correctly, the overall system had to be verified. This verification was in addition to the individual verification that had already been done.

In the methodology chapter it was suggested that the forecasts produced by the DSS be verified by comparison with results obtained through the POMANPLANS system. Further investigation of the POMANPLANS model found that this was not possible. The POMANPLANS system is based on assumptions that made comparison infeasible. The POMANPLANS model uses 10 year averages of total category promotions and separations to develop a promotion and a separation matrix. The model uses this matrix to distribute the number of promotions and separations over the category. This is quite different from the method used in the DSS and makes comparison very difficult. Another problem with the POMANPLANS model is that it is a specialist long range forecasting tool. As such, it is not designed for easy initialization and it does not clearly present a summary of results. Given this, the researcher was not confident that he could input the data and extract the results with any certainty. A comparison of the results of this model with the DSS results was not possible.

The other verification techniques described in Chapter III were performed. The first test consisted of the building of a test category in the external database and ensuring that the data from that external database loaded correctly and the forecasts calculated agreed with hand calculated data. The second test used actual historic data and compared the forecasts generated by the DSS with the actual data. The Year Zero figures used to test the DSS

were 1984 figures. The rates of separation and numbers of promotions input were based on actual data from the period 1984-1988. Using these values, forecasts were made for officer strength during the period 1985-1988.

The test data file was built, loaded and run. The results of both the DSS and the hand calculations are shown in Table 6. The forecasts obtained from the DSS are almost identical to the values calculated by hand. The differences are, again, due to allowing fractions of a person to separate in the hand calculations while rounding down to an integer value in the DSS. Rounding down the hand calculated values produced identical values to the DSS. The DSS can be considered to work correctly on the test data.

The testing of the DSS forecasts against real historic data was not as successful as the test file. Initially data was collected from the variety of sources and entered into a data file for use with the DSS. Using this data, values which were outside the bounds of rounding error appeared. The reasons for these errors appear to lie with the sources of the historic data rather than with the DSS. The historic data had be extracted from a number of sources and it appears that while some of the sources use financial years, others use calendar years. There also appears to be errors in the historic data. Unfortunately it was not possible to get all of the data required in the one format (either financial or calendar year) and so comparison became very difficult. Consider the following. The strength of one

TABLE 6

Overall Verification Using Test Data

Test 6 - Multiple Year/Rank with Test Data

FLTLT

	Yr(t)	Sep Rate	Sepns	P-In	P-Out	DSS	Err
Yr0	1000	10%	100	100	80	1000	0
Yr1	920	10%	92	100	80	920	0
Yr2	848	10%	85	100	80	848	0
Yr3	783	10%	78	100	80	783	0
Yr4	725	10%	73	100	80	724	1
Yr5	673	10%	67	100	80	671	2

SQNLDR

	Yr(t)	Sep Rate	Sepns	P-In	P-Out	DSS	Err
Yr0	500	10%	50	80	50	500	0
Yr1	480	10%	48	80	50	480	0
Yr2	462	10%	46	80	50	462	0
Yr3	446	10%	45	80	50	445	1
Yr4	431	10%	43	80	50	430	1
Yr5	418	10%	42	80	50	417	1

WGCDR

	Yr(t)	Sep Rate	Sepns	P-In	P-Out	DSS	Err
Yr0	250	10%	25	50	25	250	0
Yr1	250	10%	25	50	25	250	0
Yr2	250	10%	25	50	25	250	0
Yr3	250	10%	25	50	25	250	0
Yr4	250	10%	25	50	25	250	0
Yr5	250	10%	25	50	25	250	0

GPCAPT

	Yr(t)	Sep Rate	Sepns	P-In	P-Out	DSS	Err
Yr0	100	10%	10	25	0	100	0
Yr1	115	10%	12	25	0	115	0
Yr2	129	10%	13	25	0	128	1
Yr3	141	10%	14	25	0	140	1
Yr4	152	10%	15	25	0	151	1
Yr5	161	10%	16	25	0	160	1

rank of one category was found to be 45 in FY83 (1 July 1983 - 30 June 1984); the number of separations in FY83 was four. There were seven promotions into the rank in CY83 and eight promotions in CY84 and so a best estimate for FY83 would be

somewhere between these values. Using the model formula above, the strength in FY84 should be very close to 48. The records show that the FY84 figure was 43.

Given the quality of this data, it was not possible to properly compare the DSS with historic data. However, Table 7 does provide a comparison. It compares the actual data with the DSS and hand calculated values. The table shows that the DSS and hand calculated values were in agreement but the actual data was different. There is, however, a general agreement between the actual and DSS values. More research needs to be done to establish the actual numbers of separations, promotions and rank strengths before a full evaluation of the DSS against historical data can be performed.

Despite the limited success of the historic data as a test of the DSS, the researcher is confident that the system performs the calculations in the correct manner. His confidence is based on the test data results and the similarity between DSS forecasts and the historic data.

User Evaluation

To validate that the DSS was a tool that could support manpower decision making, a user evaluation was conducted. The next sections outline which users were selected for evaluation, how the evaluation was done and discusses the replies received to the evaluation survey.

TABLE 7

Overall Verification Using Actual 1984-1988 Data

Test 7 - Actual Data 1984-1988

	Actual Data	DSS	Error (Act-DSS)	Calc	Error (DSS-Calc)
FLTLT					
Yr0	257	257	0	257	0
Yr1	260	262	-2	262	0
Yr2	242	260	-18	260	0
Yr3	222	237	-15	238	-1
Yr4	209	210	-1	211	-1
SQNLDR					
Yr0	115	115	0	115	0
Yr1	110	100	10	100	0
Yr2	106	99	7	99	0
Yr3	123	94	29	94	0
Yr4	138	112	26	113	-1
WGCDR					
Yr0	62	62	0	62	0
Yr1	63	58	5	59	-1
Yr2	62	58	4	59	-1
Yr3	64	61	3	63	-2
Yr4	59	58	1	60	-2
GPCAPT					
Yr0	18	18	0	18	0
Yr1	20	16	4	16	0
Yr2	19	18	1	18	0
Yr3	19	17	2	17	0
Yr4	19	18	1	19	-1

The Users Selected. Two organizational areas are concerned with manpower in the RAAF. The Directorate of Personnel-Officers (DPO-AF) and the Directorate of Manpower Planning and Control (DMPC-AF). DMPC-AF is concerned with the determination of manpower needs to accomplish the service's objectives while DPO-AF attempts to fill each of the positions authorized by DMPC-AF with the most suitable person. So DMPC-AF is concerned with "spaces" while DPO-AF

is concerned with "matching faces to spaces". Both of these areas were identified as areas that face the problem of forecasting the future force structure of the RAAF, and so both are intended users of the DSS. A copy of the DSS was sent to both of these areas for user evaluation. Another area within the Personnel division is the Directorate of Personnel Computing Support (DPCS-AF). This directorate is responsible for providing computer support to the Personnel division and in particular DPO-AF. Given these responsibilities and their experience with personnel computer systems, this directorate was also sent a copy of the DSS for evaluation.

The Method Used. In total three copies of the DSS, the user guide (see Appendix D) and a covering letter were sent to Australia for evaluation. After receipt of the package had been confirmed by telephone, a time for a survey interview was set up. The time for this interview was approximately two weeks after receipt of the DSS. The evaluation survey interviews were conducted by telephone and consisted of asking the 25 questions discussed in Chapter III and attached in Appendix C. The replies received to these questions are presented and discussed in the next section. To allow the users to have more time to consider the questions and hence give more complete answers, facsimiles of the questions were sent to the users two days before each interview.

The Responses. The two Personnel division members, the DPO-AF representative and the DPCS-AF representative, evaluated the DSS individually but then gave a combined response to the questionnaire. Both of these users thoroughly tested the system. Their combined responses are designated as Respondent DPO below. The DMPC-AF user was not able to spend as much time using and evaluating the model as he would have liked due to other work commitments, however he was able to provide some feedback. To improve the quality of his responses, he asked other members of DMPC-AF to use the model and pass comments on the DSS to him. He included those comments as part of his survey answers. He is designated Respondent MPC.

An overall summary of the replies to the survey questions is presented in Table 8. The table shows that the users were in almost complete agreement although as noted in the replies each emphasized different points. The following paragraphs present the questions asked and responses received in more detail. Where appropriate, comments on the responses have been included. To delineate the questions, responses and comments, the following convention has been used: questions are underlined, the summary of the responses are both indented and in italics and the comments by the researcher use the full width of the page and are given a Comment heading.

TABLE 8

DSS Evaluation Questions and Responses

Mechanics Questions	DPO	MPC
Starting		
1. Installation Problems?	No	No
2. Start-Up Problems?	No	No
Operation		
3. Problems Understanding?	No	No
4. Data Presentation okay?	Yes	Yes
5. Questions Clear?	Yes	Yes
6. Menu System okay?	Yes	Yes
7. Recommend improvements?	Yes(1)	No
8. Overall-form and level okay?	Yes	Yes
Presentation		
9. Output Presentation okay?	Yes	Yes
10.Other forms of output	(1)	(1)
Verification		
11.Any mathematical errors?	No(1)	(2)
12.Any grammatical errors?	Yes	(2)
13.Any other errors found?	Yes	(2)
14.Operate unexpectantly?	Yes	Yes
Effectiveness Questions		
15.Assist decision making?	Yes(1)	Yes
16.Types of questions helped	(1)	(1)
17.Any other factors?	Yes	Yes
18.Types of questions not helped	Yes(1)	(2)
19.Year Zero figures useful?	Yes	Yes
20.Areas of most value	(1)	(1)
21.Strengths of the DSS	(1)	(1)
22.Weaknesses of the DSS	(1)	(2)
23.Is the DSS an effective tool?	Yes	Yes
24.Compare alternatives?	Yes(1)	Yes
25.Other comments?	Yes	Yes

(1) See text for details
(2) Not sufficient use of the system to comment

1. Did you experience any problems installing the DSS?

   Neither user experienced any problems installing the system. The steps to be followed were clearly laid out in the User Guide and were straight forward.

2. Did you experience any problems starting the DSS?

   Neither DPO nor MPC experienced any problems starting the DSS. However, comments varied on the speed of operation of the package. At one end of the spectrum was a comment that the DSS was too slow to load and operate and at the other was a comment on how fast it ran.

Comment: The researcher believes these comments relate more to the individual computer systems than to the DSS. The package will clearly run quicker on faster hardware. However, the perceived speed of this package will depend on the speed of other packages with which the user is familiar. For example, the comment complimenting the speed of the DSS was from a user running it on a 25MHz 80386DX based computer and who normally uses an integrated spreadsheet/word processing package. An integrated package would not typically be optimized for fast spreadsheet operations the way a specialist spreadsheet would be. Therefore the Quattro Pro based DSS would appear fast in comparison. Comments on the speed highlight the differences between the computer speeds and the backgrounds of the users. The user who commented on the lack of speed of the DSS agreed that it

was relative and conceded that it was "only a minor irritation".

The messages presented as initial data and parameters loaded were particularly liked by DPO. MPC did not agree with this point of view and suggested that they be blanked out.

Comment: These comments on the messages can also be related to the speed of the hardware on which the DSS is being run. The system that ran fast did not give the user enough time to fully read the messages and so annoyed him, while the user on the slower system had plenty of time to read the messages and appreciated the system keeping him informed of its progress. The value of the presentation of progress messages on a slow system is considered to outweigh the inconvenience of the messages being too quick on a fast machine. Therefore, they will be retained but a method of displaying them for longer time period on faster machines will be investigated.

3. Did you have problems understanding how to use the system? That is, did the questions flow logically, was there "computerese", was it too complex, was it too simple?

   The system was seen as easy to use by both areas. No problems were experienced with understanding the system. The level was considered appropriate.

4. <u>Was the data presented, or asked for, in the way you normally would use it</u>?

The answers to this question can be summarized with the DPO quote, "in general, yes". The specific areas that the users expressed concern about were the lack of definitions, the term "Lateral Out", the term "Ideal Structure" and the term "Grade". DPO requested that definitions of all input variables be given in the User Guide. Although most variables were well known and an accepted definition exists, this is not the case for all of the variables. To save misinterpretation and to ensure that all forecasts are comparable, all terms must be defined.

<u>Comment</u>: A definition section needs to be added to the User Guide.

DPO advised that they include the number of people who move laterally out of one category in the number of separations from that category. Therefore, DPO suggest that a distinct variable, "Lateral Out", is not required.

<u>Comment</u>: The researcher does not believe that this is a correct interpretation of the term separation rate. This disagreement needs to be investigated. Until the situation is clarified, the term will remain in the model. To meet the requirements of DPO before clarification, the number of

lateral movements can be included in the separation rate and the Lateral Out variable set to zero.

Both respondents questioned the use of the term "ideal structure".

Comment: This term will be changed to "constrained establishment" or "CE" to more accurately define the numbers presented.

The term "Grade" was seen as a USAF term rather than a RAAF one and its replacement with the word "Rank" was suggested.

Comment: The word grade will be changed to Rank.

5. Was the presentation of the questions clear? Did you understand what and why you were being asked a particular question?

   Both users were happy with the presentation of the questions. The system was considered easy to use and follow given the background of the users. The user background of both areas included using a variety of spreadsheets such as Microsoft Excel, Open Access, Lotus 1-2-3 and Quattro Pro. DPO commented that knowledge of Quattro Pro was not necessary and the operation of the DSS was quickly mastered.

6. To what extent did the menu system hinder or help you?

   The menu system was seen as a major strength of the DSS by the users. The menu system, in conjunction with the underlying DSS, automated a

number of functions that are presently done manually and this was seen as a major advance. It also simplified using the system and hence decreased the reliance on managers having an indepth knowledge of the formulas involved in manpower modelling.

7. Can you recommend improvements to the interaction between you and the computer?

   DPO suggested that error recovery be improved in some areas. He highlighted a problem with the error recovery using the <Esc> key. In most cases the <Esc> key could be used to back out of a problem, but in a few isolated cases this was not possible. This inconsistency led to confusion in the user's mind as to how the system operated and reduced confidence in the system. It also occasionally led to the loss of data as the user either became locked in a menu and could not return or escape from the DSS entirely and could not rejoin the DSS. Both of these situations forced the user to re-initialize the computer and consequently lose all current work.

Comment: The error trapping functions of Quattro Pro are somewhat limited in this area but an attempt should be made to strengthen the error capture and error recovery of the DSS. Particular emphasis should be given to standardizing

the error trapping so that the operation of the DSS is consistent.

8. <u>Overall, was the form and level of the operation okay</u>?

   Both users stated that they were generally very happy with the way in which the DSS interacted with the user. The level of communication was correct and the menu system was seen as a real advance over present systems. Provided all terms were defined, the system could be used to assist with decisions after a very short learning period.

9. <u>To what extent did the presentation of output data meet your requirements</u>?

   The users considered the graphs already in the system as very useful. This was particularly true for DPO. At present they produce similar graphs on a six monthly basis using a less automated and more manpower intensive processes. However, a change in procedures is expected to require them to produce these graphs on a monthly basis. This change in procedures was seen as a considerable extra burden for DPO. The use of the DSS should allow these graphs to be produced with little user input and therefore maintain the present workload rather than have it increase.

10. <u>What other forms of output are required or would be useful</u>?

    Both areas requested that more types of graphs be

added. MPC stated that a graph that compared the current establishment with a scenario establishment would be very useful. He explained that he had seen an Royal Australian Navy (RAN) system which plotted a 3-D graph of a category with rank on one axis, establishment on the second and present and proposed establishment on the third axis. Such a graph could be a powerful persuasion tool as it would quickly highlight the significant changes between the present pyramid shape and a proposed or forecast one.

A graph that both areas would like to see incorporated was a graph of separation rate versus years of service. DPO would also like to see more statistical analysis graphs, for example, a regression analysis of separation rates.

Comment: The suggestion of the Present versus Proposed Establishment and Separation Rate versus Years of Service will be incorporated into the final DSS. Some statistical analysis graphs will also be available from within the DSS. Further discussion with the users is required to understand their exact requirements but it seems that some of the graphs are more the tools of a statistics practitioner than the tools of a management decision aid.

DPO would like see the ability to add text to the graphs before printing them added to the output functions of the DSS.

Comment: Quattro Pro has a very powerful and useful annotator function that can be used to add text and highlight features of a graph. However, more Quattro Pro expertise is required to use this feature than the DSS assumes. The role of graph annotation is also seen as outside the scope of the DSS. However, to accommodate users with the expertise and the need, it may be possible to give the user an option to leave the DSS menu system and then resume after annotating the graphs. Overall, the incorporation of this feature is considered a low priority task and perhaps outside the scope of the project.

11. Did you detect any mathematical errors in the DSS?

    Neither user detected any mathematical errors but both added that they had not fully tested the models.

12. Did you detect any grammatical errors in the DSS?

    Only one misspelling had been detected. The word forecast had been misspelt as "forcecast" on one of the graph displays.

Comment: The misspelling will be corrected.

13. Did you find any other sorts of errors in the DSS?

    One group noted that the menu selection for a graph was By Grade, By Year or Both. This meant that the letter B was pressed no matter what the choice was from the menu. This lead to confusion as to which graph type had actually been selected and was being displayed.

<u>Comment</u>: The wording of the menu will be changed to ensure each choice on the menu has a unique designator.

> *The "Save Work" selection was not as robust as the other parts of the DSS and did not appear to recover particularly well from input errors.*

<u>Comment</u>: More work needs to be done on the Save module of the DSS. Shortcomings in the error recovery procedures of Quattro Pro need to be studied and overcome to ensure that forecast data is not lost and that users are not ejected from the DSS menu system.

14. <u>Did you find that the program operated in an unexpected manner at any time? For instance, did you find that you were no longer connected to the menu system</u>?

> *A couple of bugs were found in the DSS. One was that one of the graphs did not have a <Quit> button and looked different from the others of this variety.*

<u>Comment</u>: This resulted from a bad call function in the DSS and will be corrected.

> *Another bug discovered by the users was that while some variables would allow the user to enter the value zero, others would not and gave an error message.*

<u>Comment</u>: Zero is a valid entry and an error message should not be given. Unfortunately in Quattro Pro, zero requires special handling. The error handling routines will all be

checked and revised where necessary to ensure that they all handle zero correctly and in the same manner.

The problem of using <Esc> to "back out" of a routine was again mentioned by the users.

Comment: See Question 7.

15. If you are making a decision concerning the future force structure, to what extent does this DSS assist you with your decision making?

    The users rated the DSS high as an aid to their decision making. The DSS automated a number of functions that presently must be done manually or require the combining of data from a number of sources. This automation standardized and structured their thinking, facilitating better decisions.

16. What types of questions does the DSS help with?

    The users commented that the DSS helped with the what-if questions on manpower and it did the tasks it aimed to do, as outlined in the User Guide (Appendix D), namely,

> The RAAF Officer Structure Decision Support System (DSS) is a tool for forecasting the future structure of the RAAF. . . In addition to forecasting using historical data, it allows the user to enter his own predictions of what the future rates of separation, promotion and recruitment will be.
>
> The aim of the DSS is to provide a tool to manpower and personnel managers that will allow them to do what-if analysis on possible changes to

personnel policy and make comparisons using a common baseline.

A particular strength, as expressed by DPO, was the ability to make a comparison of the ideal (establishment) figures with the actual strengths, both at the present and in the future. This ability helped answer questions on how our force structure compared with the ideal. MPC commented favorably on the ability to see the future structure of a category given some change in policy.

17. Are there other factors that should be included in the DSS?

DPO felt that it would improve the usefulness of the DSS if the user had the ability to override the default values for actual and ideal strength.

Comment: The data known to the user is normally more current than the data held by the computer. Given this and the increased flexibility of the system that changing the default values would allow, a change will be incorporated into the DSS to let users override the default strength and establishment figures. In addition, a comment will be displayed on the graphs noting that the figures used are based on the user input rather than actual data.

18. What types of questions does the DSS not help with?

The users suggested recruiting targets as one area where the DSS would not be of assistance.

Comment: Firstly, finding recruiting targets is seen as outside the scope of the objectives of this project. Secondly, the researcher agrees that recruiting targets are not easy to obtain from the system. But it is not correct to say that they cannot be obtained. To obtain a recruiting target would require the user to use an iterative process of entering a different number of recruits into the present structure and viewing the future structure. This iterative process would continue until the desired future structure was obtained. This is not the best method of finding the number of recruits required and the "bottom up" flow of the DSS is clearly not the best way to calculate the figures required. More research needs to be done in this area to find if the present *POMANPLANS model method of calculating* targets can be incorporated into this DSS or whether their present system already provides an adequate forecast.

> *Other areas with which the DSS did not help were regression analysis of separation rates and, related to this, the prediction of future separation rates.*

Comments: Both of these areas are seen as outside the objectives of this project although some presentation of trends could be included. At present the calculation of separation rates is done separately to the DSS. Only this calculated historical separation rate is entered into the system. However, a presentation of regression analysis

would allow the user to make a judgement on future rates. These modified rates could then be entered into the DSS.

19. <u>Are the year zero figures of value to you</u>?

    Both areas commented that the year zero figures were useful as they provided a ready reference and consolidated data which is presently found in a number of separate databases or in different reports.

20. <u>Which areas of the DSS are of most value to you</u>?

    The areas of most value were seen as the graphic capability and the what-if capability. The task of generating graphs of strength versus established positions for each of the categories are required on a regular basis. At present each of these graphs is produced after reference to a number of databases and manually entering the data into a spreadsheet. The DSS provides the graphs required automatically, in a standardized form, in a fraction of the time. In addition to routine graphs, both areas are continually asked what-if questions concerning the structure of the force. At present, specific research and calculations are done for each of these questions. The DSS was seen as a tool which would allow answers to a number of these questions to be found with minimal effort. Essentially the DSS automated a number of the tasks that presently are done manually.

21. What do you consider to be the strengths of the system?

The friendly user interface was seen as the major strength by both users. The feature that made the interface friendly was the menu system. The menu system was seen as a real advance over present systems, which were not designed for use by managers but rather only by computer specialists.

22. What do you consider to be the weaknesses of the system?

Neither user suggested any major weaknesses.

23. Is the DSS an effective tool for forecasting the future force structure?

Both users agreed that the DSS was effective tool for forecasting the future force structure. Where most experienced managers were able to provide guidance on the future structure, the DSS helped to put this subjective guidance into a quantitative form. As DPO commented "It reinforces the gut feel".

24. To what extent does the DSS allow you to compare alternative strategies or policies?

The consensus on this question was that "in general, yes; but it depends". The actual policies or strategies being compared would govern whether the DSS allowed a comparison to take place. Whereas a number of possible scenarios can be addressed by the DSS, others cannot. DPO

pointed out that the DSS does not cover all of the environmental factors that affect the future structure and so it depends on which factors are affected by the policy or strategy under consideration. One particular factor missing was the effect of return of service obligation (ROSO).

<u>Comment</u>: The researcher agrees that not all environmental factors have been considered and that the evaluation DSS was limited in this area. However, the significant factors that influence the force structure were considered in Chapter II. Some of these factors were included in the core DSS, and most of the remainder will be included in the final version. The influence of ROSO was one of the major factors identified. As discussed earlier in this chapter, the relationship between ROSO and other factors need to be established before it can be incorporated into the DSS.

25. <u>Other comments</u>?

MPC related their need to consider both the enlisted force and the officer force. A political decision had recently been made to reduce the size of the RAAF by 4200 positions (a 20% reduction in size). The responsibility of identifying which individual positions were to be made redundant had been delegated to the Chief of Air Staff and he, in turn, had delegated it to DMPC-AF. The redundant positions will include both enlisted and officer but most will be enlisted positions.

Given this task, the DSS was seen as a very useful tool when considering officers. The benefits of ease of use, graphical presentation and automation provided by the DSS were all recognized. However, since most of the work was being done on the enlisted force the inclusion of enlisted data was seen as an improvement to the system.

<u>Comment</u>: This application is outside the scope of this particular project, but a follow-on project could build an enlisted version of the DSS.

DPO expressed the wish that the equations used in the DSS be included in the User Guide. This would help to increase the user confidence in the system and help explain discrepancies between this DSS and other forecasting methods.

<u>Comment</u>: The equations will be included in the User Guide.

<u>Summary of User Recommendations</u>

The user evaluation provided a number of suggestions to improve the usefulness and effectiveness of the DSS. The recommendations were:

a. Change the User Guide to include definitions of all terms. The inclusion of definitions would save misinterpretation of terms and ensure forecasts were comparable.

b. Make some grammatical and operational changes to the DSS. These changes include correcting a

couple of "bugs", standardizing error handling, correcting spelling mistakes and handling of the value zero in a consistent manner.

c. Improve the error handling of the DSS. Although a number of error recovery routines are in place, more can be added.

d. Investigate the inclusion of additional graphs. Graphs of years of service versus separation rate, current establishment versus proposed establishment and regression analysis of separation rates are some of those suggested by the users.

e. Investigate whether this DSS should be expanded in scope to include the tasks performed by manpower specialists, or whether other similar systems should be developed for these specialist tasks. The ease of use and automation that this DSS brings to management problems can be applied in a number of other areas. Manpower specialists suggested a number of similar tasks where a modified version of this DSS could be used; for example, in the calculation of recruiting targets. More research needs to be done to decide whether one "all encompassing" system is the best solution or whether a number of smaller, more specialized systems are the best course of action.

Conclusion

This chapter has presented the processes used to develop the DSS and then analyzed the user evaluation of the core DSS. The development began with the building of the database and modelling modules. These were the central components of the system. Onto this base were added the database interface, reset, save, graph, print and parameter modification modules. These modules formed the core DSS. As each of these modules was developed, the tasks it performed were verified against a test set of data. All modules handled the data and calculations correctly. After individual testing of the modules, an overall verification was performed. This verification was done in two phases. The first produced forecasts correctly from a test data file; the second forecast the structures for 1985 through 1988 given data on 1984 and the appropriate rates.

The first verification test was completed successfully. Forecasts were produced which were the same as the test data. The second test was not as successful. Problems with inconsistent and possibly incorrect data made comparison very difficult. Despite the problems with the verification against actual data, these tests produced confidence that the DSS operated correctly.

The core DSS was provided to three organizations for evaluation. Two of these areas consolidated their responses and so two responses were received. Overall, they had no trouble operating the DSS, validated that the DSS addressed

the problem, and suggested changes and enhancements to the system. They rated the menu system and the graphic presentation as the major advances over present systems.

The major aim of the user evaluation was to validate that the DSS was an effective tool in assisting managers to make decisions concerning future force structures. The user evaluation rated the DSS "high" as a useful decision tool, but added that further enhancements could be added.

Given that the system has been validated as useful, the final phases of the project need to be completed. These phases are the development of the advanced modules, the incorporation of the changes and enhancements suggested by the users, and the implementation of the system.

V. Conclusion and Recommendations

Introduction

Experienced people are one of the most valuable resources the RAAF has. However, private industry also recognizes the value of RAAF trained people. Consequently, there is a continual migration of people from the service to join the civilian workforce. Due to the small size of the RAAF (3,500 officers), upward fluctuation in this loss or separation rate can have quite a severe impact on the RAAF organizational structure. The impact is felt though the dilution of experience, the increased training costs, and the loss of morale of those that remain in the service.

RAAF manpower and personnel managers have limited correction capability or flexibility in the short term. The only avenue open to managers is to closely monitor the manpower resource and put in place policy that will have an effect in the medium to long term. The monitoring of the manpower force and the identification of any possible problems are done by forecasting. Combining forecasting with "what-if" scenarios allows evaluation of different situations and manpower policy. *What if 50 more pilots than expected resign this year? What if we recruit 30 more engineers this year? What if we put a freeze on resignations for two years?* Comparison of the results of these *what-if* scenarios suggest the route that managers

should adopt and hence help support decision making.

RAAF manpower managers presently do not have an automated method of considering these questions or accessing forecasts on the future structure of the officer corps. The lack of this tool has forced individual managers to make their own predictions. The predictions are often calculated using different baselines, making different assumptions, using different modelling techniques and with varying levels of expertise. Anyone of these makes comparison of the results misleading or inaccurate. Given the importance and the cost of the manpower resource, an automated tool should be available to ensure that all forecasts and answers to *what-if* questions are based on the same data.

The objective of this research was to address this deficiency. It endeavored to do this through the provision of an integrated system that supported decision making on the force structure. In addition to developing the system, the research sought to determine that the system supplied did address the lack of an integrated forecasting system. To reach these objectives, a number of questions had to be answered. Those answers and appropriate recommendations follow.

The Research Questions

In Chapter I, a series of questions were presented that required answers if the research was to meet its objectives. The first three questions were studied in Chapter II, the

final two were studied in Chapters III and IV. The answers to these questions are presented below.

The first question was:

What is the best way to provide a manpower structure modelling capability? Is it by using a simulation model, an analytical mathematical model, or some other method?

The literature review found that a number of modelling methods could be applied to the manpower forecasting problem. However, for medium to long term forecasts, as required by RAAF decision makers, an analytical mathematical model was found to provide a good solution. It was one of the most commonly used methods. A variation of the analytical mathematical model known as an Inventory Projection Model (IPM) was the most common manpower model used and the most appropriate for this project. It considers the manpower force as inventory and recruitment, promotion and separation rates as the determinants of system throughput. Other alternatives were found to provide only a partial solution, to be too complex or not as well suited to the RAAF problem as the IPM model.

Having found a method of modelling the force structure, a mechanism by which the overall forecasting process could be integrated and automated was required. This interaction between the manager and modelling suggested that a decision support system (DSS) may be a possible tool. A DSS links a user interactively through a computer to both data and to a

modelling system. Through this linking a computer system is produced which aids management "in making effective decisions in those areas where both management judgement and computer analysis are required" (1:129). Such a description certainly fits the RAAF situation. Given the possible benefits from this approach the second question was asked:

> *Would a decision support system be an appropriate method of providing the management support required?*

The literature review and the responses of RAAF managers who used a prototype DSS was that a DSS is an appropriate method of providing manpower management support.

To meet their needs, the RAAF requires three components--a database, a model base and an interactive link with the manager. A database to hold the present force and data on historical rates of separation, promotion and recruitment. A modelling system, as described in answer to the first question, is required to forecast the future structure. A link between the manager and the computer system is also required. It must communicate with the manager in terms that he understands and must provide output in a form that is understood and useful to the manager.

These three components required by the RAAF--a database, a model base and user dialogue system--are the same components that define a DSS, and are therefore found in all DSSs. The areas most suited to use of a DSS include ones in which the problem is continuously changing, answers

are needed quickly, data are continuously changing, data come from a variety of sources, and data output is required in a variety of forms. The RAAF situation is one where answers are required quickly, the data are continually changing and the data come from a variety of sources. The RAAF system clearly fits a number of the categories addressed by a DSS and it requires the same components as those provided by a DSS.

Users evaluated a prototype manpower DSS as part of this research. They found that the DSS did assist with a number of the problems facing manpower managers. It automated a number of functions that were presently done manually, gave quicker access to information and provided a more structured approach to decision making. This evaluation validated that a DSS was an effective tool and an appropriate method of supporting manpower management.

The appropriate model to use, an IPM, and an appropriate environment, a DSS, have now been established. The factors that influence the future shape of the RAAF officer structure need to be established so that they can be incorporated into the DSS model. This leads to the third question:

> *What factors are significant and how do they interact in the manpower structure? Can these factors be incorporated into the models?*

From the literature review, it was found that the future structure of the force could be forecast using the

present composition, the recruitment rate, the promotion rate, and the separation rate. To provide a decision making capability the factors that influence these rates also needed to be included. While the total number of factors that have an influence is infinite, a number of significant, common, measurable factors can be found. A review of the factors used in other manpower models provided a list of possible candidate factors. From this list those relevant to the RAAF were chosen. The significant factors that influenced the recruitment rate and were relevant to the RAAF were found to be the number accepted and category. The significant factors that influenced the separation rate were rank, category, years of service, obligation, and retirement considerations such as minimum age and minimum length of service. The factors that influenced the promotion rate were the qualifications held on entry into the service, the rank, the category and the historical promotion rate. Other factors that influenced the structure were the limits placed on categories and ranks, and the overall limit on the system of the service.

Other factors were found to influence an individual but were not considered significant in aggregate movement rates. Examples of these were the performance of an officer and special qualifications.

During development of the DSS and the integration of these factors into the model, two areas where more research is required became evident. The first relates to the

recording of RAAF officer data. Traditionally, the data on officers has been recorded using time in rank rather than years of service (YOS). Almost no data was available in the YOS form. As the separation factor *Minimum Retirement Time* is more closely related to YOS rather than years in rank, this factor will not be incorporated into the DSS until data based on YOS is available. This reduces the ease with which changes in retirement time can be examined but does not limit the DSS.

The second area where more research is required is that of the distribution of officers within categories and ranks. This research was unable to find a standard distribution that adequately described the various types of officers. The solution for this DSS is to import data for the actual distribution for each rank within each category. This requires a greater amount of data storage but is considered the best solution at present. It does have the advantage of allowing management to see the actual current distribution and make decisions on each individual group. More research needs to be conducted in this area to establish if there is a relationship between YOS or years in rank and the separation rate. Similar research needs to be done to establish if there is a relationship between YOS and the promotion rate. The actual distribution will be used in the DSS at present.

To be able to provide decision support, the DSS needs more than a model and the factors that influence it. The

DSS must be able to present its forecasts or findings in a manner that management can understand and use. The fourth question that this research had to answer was concerned with this aspect of the problem.

> *What information is required by management to support decision making in this area? In what form is the information required?*

The answers to this problem came initially from the experience of the researcher and discussions with the users. From this research, it appeared that the information required by management was trend and comparison information. Access to trend information would allow management to make early decisions and initiate changes to policy to avoid structural problems. In the past problems had been detected too late and short term "fixes" had been applied with limited success. Early detection via trend information would help to avoid this situation. Access to comparison information would allow management to examine different possible solutions. The DSS facilitates these comparisons and ensures a similar baseline is used for each scenario.

User discussions also led the researcher to believe that the best way of presenting results was through the use of graphs. Both trend analysis and comparisons, are easily done using a graphical presentation. A graph allows the whole picture to be seen, without loss of detail. For example, it is often difficult to see an overall trend in data when it is presented in a tableau form. The same data

presented in graphical form allows the eye to integrate the data and distinguish any underlying trend. In addition to the trend now being visible, the graph still contains all of the detail that was contained in the numerical table. The graphical output simply emphasizes the overall or aggregate result. This aggregate trend information is the support normally required by manpower managers.

To confirm the researcher's evaluation of the users' information needs and the form they should take, a prototype DSS was sent to potential users of this system for appraisal. After the users had used the system, a series of questions were asked. In these questions (Appendix C) the users were asked to comment on how well the DSS met their requirements, where improvements could be made, whether the graphs included with the DSS were useful, and whether other graphs needed to be added. In response to these questions, the users rated the system "high" as an aid to their decision making. This validated that the information required for decision making was being supplied. They also commented that although the graphs supplied were very useful, more comparison graphs were required. Most of the suggested additional graphs will be part of the final system produced by this research.

Having found the type of model, the factors, the type of output and the environment required, the final question that needed to be answered was how effective was the system. The final question was:

To what extent does the system allow management to solve this problem?

Again, the method used to answer this was the user evaluation. In addition to questions on the operation of the DSS, users were asked questions on its usefulness and effectiveness. In general, the users found that the system was a very useful tool. The automation, graphic presentation, and user friendliness of the system were seen as a major steps forward and as effective support aids in the decision process.

The major strength of the DSS was seen as its ability to take a complex problem and simplify it to a level where comparisons of different policies could be examined. This provided a better basis for decision making by manpower and personnel managers.

Other strengths of the system were its user friendliness, its *what-if* capability, its simple operation and its time-saving characteristics. The system was developed on a spreadsheet. This meant most managers were comfortable operating the system. The DSS was also completely menu driven which further simplified use of the system. The automation and menu system also increased the robustness of the DSS to errors and added to its integrity. The final strength of the system was its time saving features. By combining a number of data sources into one and automating it, managers were able to find details of how

many or what rate without having to get computer specialists to search through the mainframe databases.

However the DSS did not address all problems. A weakness in the prototype system was its database updating. In the evaluation DSS, updating was done manually from the CATSIT report. The final version will extract data from a number of databases automatically and this problem should be eliminated.

Some other areas were suggested for enhancement or improvement. While a number of these will be included in the final system, others were considered outside the scope of this project. As the DSS was developed for management decision support, a number of the more advanced specialist analysis tools were considered outside the scope and omitted from this DSS. Some other suggested enhancements require more research before inclusion can be considered.

Overall, the DSS was seen as a step in the right direction and an effective management tool. The implementation phase of the system will proceed.

Recommendations

Two types of recommendation come from this research. The first type are concerned with changes to the DSS. A summary of these recommendations is presented at the end of Chapter IV. The second type of recommendations are concerned with more general issues that have arisen during the development of the manpower DSS.

The research found that further research was required in the following areas:

a. The definition of the ideal structure of the RAAF officer corps. The work done in the past has used the notion that an ideal structure is a sustainable structure. This perception needs to be proven and the direction of the sustenance needs to be found. Should the number of officers at the top be the driving force or the number of officers at the bottom.

b. Lower limits on categories need to be established. All organizations in the RAAF have a "Constrained Establishment", an authorized number of positions. This constrained establishment effectively serves as an upper limit on the number of people in an organization. There is no lower limit. Management of manpower could be improved if a lower limit were available. The limit could be used to trigger a warning that action was required. It could also be used as an automation tool for highlighting future problem areas.

c. A precise definition of all manpower terms needs to be established. It is not possible to compare strategies if the same term implies different things to different people. For example, the loose definition of separation rate allows some organizations to have two distinct terms,

separations and *lateral movement out*, while others have only one term, *separations*, that covers both. Given such inconsistencies, differences in estimates and data are to be expected. Precise definitions would eliminate this type of difference.

d. The collection of more data is required if personnel management is to be improved. Data based on years of service (YOS) is one area that is presently not collected and could provide a significant improvement in the modelling and management of manpower. In particular, the relationship between YOS and separation rate seems to provide a strong connection. Data on the number of people serving under ROSO is not collected. Again the collection of this data could improve the management of this expensive and scarce resource.

e. A similar DSS system for the enlisted force needs to be developed. Force reduction is taking place in a number of countries, including the United States and Australia. The DSS developed by this research should provide valuable support with decisions on how to perform the deduction of the officer force. However, the factors that affect enlisted force are different and a separate system needs to be developed.

Conclusion

The objective of this research was to develop a system that would address the problems presently encountered in RAAF manpower structure forecasting. The research did this through the development of a decision support system. The DSS provides an integrated forecasting system based on objective, reliable data. With this kind of support, manpower managers are able to make informed decisions on the structure of the future officer force.

A prototype DSS, consisting of the core modules, was evaluated by users. The response from these users was that the DSS was a useful tool and did address the lack of an integrated tool. However, they added that the system did not address all areas.

Some of the areas that have not been addressed are a result of a lack of data. Data on personnel serving under ROSO and data on years of service are not currently available. Both of these are factors that influence the force structure. The usefulness of the DSS would be increased if these factors were available. Until the data are available, less reliable and indirect methods will have to be used to support decisions on areas influenced by these factors.

Overall, the user feedback validated the DSS. Given this validation the final stages of the development will now be completed. These are the inclusion of the advanced modules and the enhancements suggested by the users. These

will be completed by the researcher on his return to Australia where he is to be employed in this area of manpower management and has direct access to data and other systems.

The research has recommended that action should be taken to improve the manpower management of the RAAF. The recommendations include the collection of more data, the development of a similar model for the enlisted force, standardization of manpower definitions and the introduction of lower limit triggers on establishments. Each of these recommendations will allow the introduction of more automated and comprehensive systems to assist with the problems facing manpower managers.

Appendix A: Rank Comparison Chart

RAAF	USAF	NAVY
Air Chief Marshal	General	Admiral
Air Marshal	Lieutenant General	Vice Admiral
Air Vice Marshal	Major General	Rear Admiral
Air Commodore	Brigadier General	Commodore
Group Captain	Colonel	Captain
Wing Commander	Lieutenant Colonel	Commander
Squadron Leader	Major	Lieutenant Commander
Flight Lieutenant	Captain	Lieutenant
Flying Officer	First Lieutenant	Lieutenant J.G.
Pilot Officer	Second Lieutenant	Ensign

Appendix B: Comparison of Factors in Six Operational Models

MODEL=>	TOPLINE	DOPMS	OSSM
RECRUITMENT RATE			
Quality of Applicants			
Number of Applicants			
Training Rate (Output)	x	x	x
Limits		x	
PROMOTION RATE			
Entrance Method	x	x	x
Grade/Rank	x	x	x
Category/AFSC	x	x	x
Time in Rank			x
Years of Service	x	x	x
Historic Promotion Rate	x		x
Limits on Promotions			
Cohort/OER			x
SEPARATION RATE			
Source		x	
Grade/Rank		x	x
Category/AFSC	x	x	x
Years of Service	x	x	x
Obligation	x	x	x
Force-Out Points	x	x	
Promotion Opportunities	x		
Retirement Age/Time	x	x	x
Time (date)			
Augmentation		x	x
External Conditions			
Education			
Race			
Sex			
OTHER			
Cost		x	x
Targets		x	
Future Compensation			

MODEL=>	EFMS	ROS	ARMY MLRPS
RECRUITMENT RATE			
Quality of Applicants			x
Number of Applicants	x		
Training Rate (Output)	x	x	x
Limits	x	x	x
PROMOTION RATE			
Entrance Method			
Grade/Rank	x	x	x
Category/AFSC	x	x	
Time in Rank	x	x	
Years of Service	x	x	x
Historic Promotion Rate	x		
Limits on Promotions		x	x
Cohort/OER	x		x
SEPARATION RATE			
Source			
Grade/Rank	x		x
Category/AFSC	x	x	
Years of Service		x	x
Obligation	x		
Force-Out Points			
Promotion Opportunities	x		
Retirement Age/Time			x
Time (date)	x		x
Augmentation			
External Conditions	x		
Education	x		
Race	x		
Sex	x		
OTHER			
Cost	x	x	
Targets	x		x
Future Compensation	x		

	Occurrence of Factor
RECRUITMENT RATE	
Quality of Applicants	1
Number of Applicants	1
Training Rate (Output)	6
Limits	4
PROMOTION RATE	
Entrance Method	3
Grade/Rank	6
Category/AFSC	5
Time in Rank	3
Years of Service	6
Historic Promotion Rate	3
Limits on Promotions	2
Cohort/OER	3
SEPARATION RATE	
Source	1
Grade/Rank	4
Category/AFSC	5
Years of Service	5
Obligation	4
Force-Out Points	2
Promotion Opportunities	2
Retirement Age/Time	4
Time (date)	2
Augmentation	2
External Conditions	1
Education	1
Race	1
Sex	1
OTHER	
Cost	4
Targets	3
Future Compensation	1

Appendix C: User Evaluation Questionnaire

Questions on the Core DSS

The questions are of two kinds--mechanics and effectiveness. The mechanics questions concern the use of the DSS while the effectiveness questions relate to how well it meets their needs.

Mechanics Questions

Starting

1. Did you experience any problems installing the DSS?

2. Did you experience any problems starting the DSS?

Operation

3. Did you have problems understanding how to use the system? That is, did the questions flow logically, was there "computerese", was it too complex, was it too simple?

4. Was the data presented, or asked for, in the way you normally would use it?

5. Was the presentation of the questions clear? Did you understand what and why you were being asked a particular question?

6. To what extent did the menu system hinder or help you?

7. Can you recommend improvements to the interaction between you and the computer?

8. Overall, was the form and level of the operation okay?

Presentation

9. To what extent did the presentation of output data meet your requirements?

10. What other forms of output are required or would be useful?

Verification

11. Did you detect any mathematical errors in the DSS?

12. Did you detect any grammatical errors in the DSS?

13. Did you find any other sorts of errors in the DSS?

14. Did you find that the program operated in an unexpected manner at any time. For instance, did you find that you were no longer connected to the menu system?

Effectiveness Questions

15. If you are making a decision concerning the future force structure, to what extent does this DSS assist you with your decision making?

16. What types of questions does the DSS help with?

17. Are there other factors that should be included in the DSS?

18. What types of questions does the DSS not help with?

19. Are the year zero figures of value to you?

20. Which areas of the DSS are of most value to you?

21. What do you consider to be the strengths of the system?

22. What do you consider to be the weaknesses of the system?

23. Is the DSS an effective tool for forecasting the future force structure?

24. To what extent does the DSS allow you to compare alternative strategies or policies?

25. Other Comments?

THANK-YOU

Appendix D: DSS User Guide

THE RAAF OFFICER STRUCTURE DECISION SUPPORT SYSTEM USER GUIDE

The RAAF Officer Structure Decision Support System (DSS) is a tool for forecasting the future structure of the RAAF. It uses historical data and data on the present numbers of officers in each category to forecast the numbers of officers at each grade for the next five years. In addition to forecasting using historical data, it allows the user to enter his own predictions of what the future rates of separation, promotion and recruitment will be. The results of the user's scenario can be easily displayed.

The aim of the DSS is to provide a tool to manpower and personnel managers that will allow them to do *what-if* analysis on possible changes to personnel policy and make comparisons using a common baseline.

This user guide contains the installation instructions, and directions for using the RAAF Officer Structure Decision Support System (DSS).

Installation

The DSS is designed to run on an IBM-PC/AT computer. It requires a hard disk but does not need extended or expanded memory. The DSS can be operated by either a mouse or keyboard and CGA is sufficient to use the program although EGA or better is recommended.

The DSS requires that Quattro Pro version 2.0 (called QPRO from here on) or later is installed on your system. Quattro Pro is a spreadsheet program very similar to Lotus 1-2-3. Most people who have used a spreadsheet before will have not any trouble using QPRO or the DSS.

To install Quattro Pro (QPRO) on your hard disk:

- o Place QPRO Disk 1 in drive A.
- o Type A:INSTALL and press <Enter>.

o Follow the directions that display on-screen.
o There is no requirement to install the fonts.

If you have difficulty reading the screens during the install program, use the optional command line parameter, /B to force Install to use a black and white display. Type

A:INSTALL /B<ENTER>

It may be necessary to specify the /B parameter if you are using an LCD screen or a system that has a color graphics adapter with a monochrome or composite monitor.

After installing Quattro Pro, the DSS disk itself must be copied to the same subdirectory as QPRO. Do this by putting the "RAAF STRUCTURE DSS" disk in drive A. Type

```
C:          <Enter>
CD\QPRO     <Enter>
COPY A:*.* <Enter>
```

The DSS is now installed and ready to run. **Note**. The first time the DSS is run there will be a number of delays while QPRO builds fonts for the various displays. As these fonts are built, they are saved onto the hard disk and are called up instantly after that initial build.

Starting the DSS

To start the DSS, you need to load QPRO and then load the DSS program. To do this type

Q <Enter>

This will load Quattro Pro, then to load the program, you need to retrieve the file DSS.WQ1. Press

/fr

and select the file **DSS.WQ1**

Once the file has loaded, the program will start automatically and the opening message displayed below should be seen.

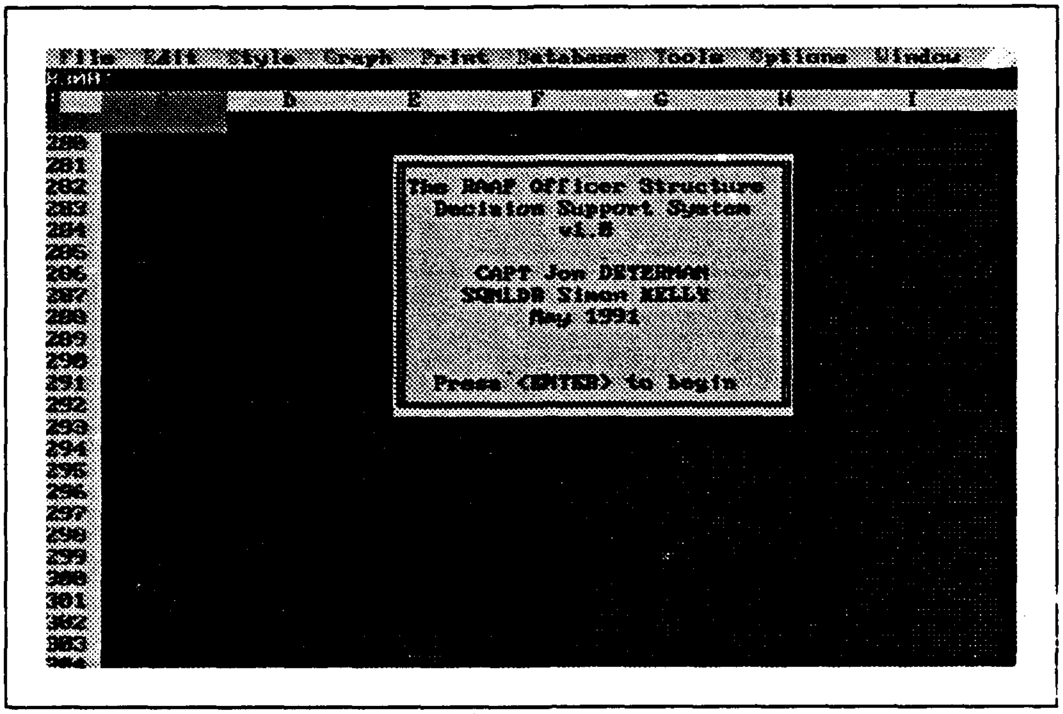

Figure D-1 The Initial Screen on Start-Up

Pressing the <Enter> key or clicking on a mouse will start the program. The first menu allows the selection of the category of the RAAF that is to be examined. The selection can be made using a mouse or by moving the light bar up and down with the cursor keys and then making a selection with the <Enter> key. The choice can be changed at a later stage in the program.

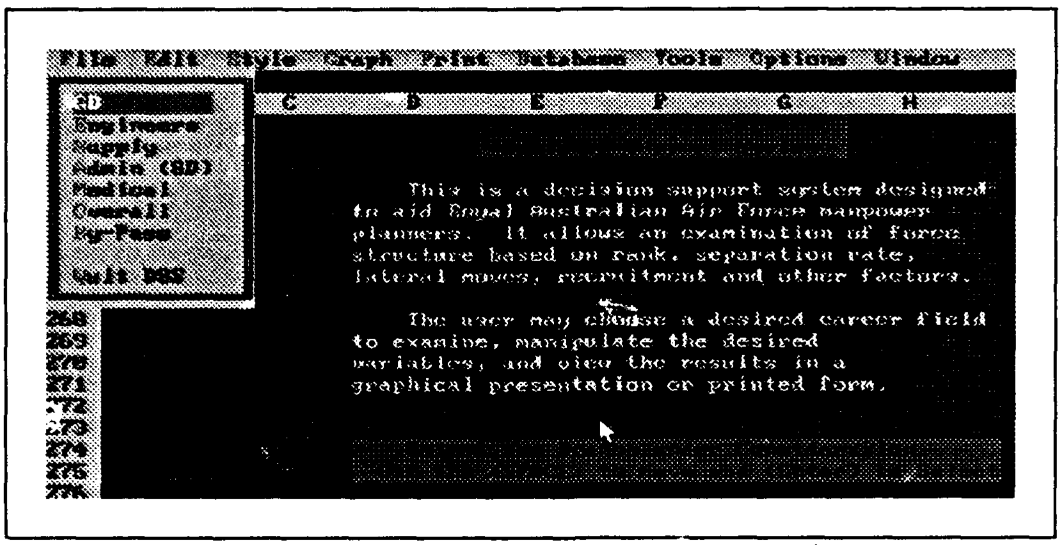

Figure D-2 The Branch/Category Selection Menu

There is a delay of a few seconds as the data for the category is loaded; this is because the program not only loads the data but also resets all the field in the model. After a selection of a category of Off· er and the resetting is complete, the main menu is displayed.

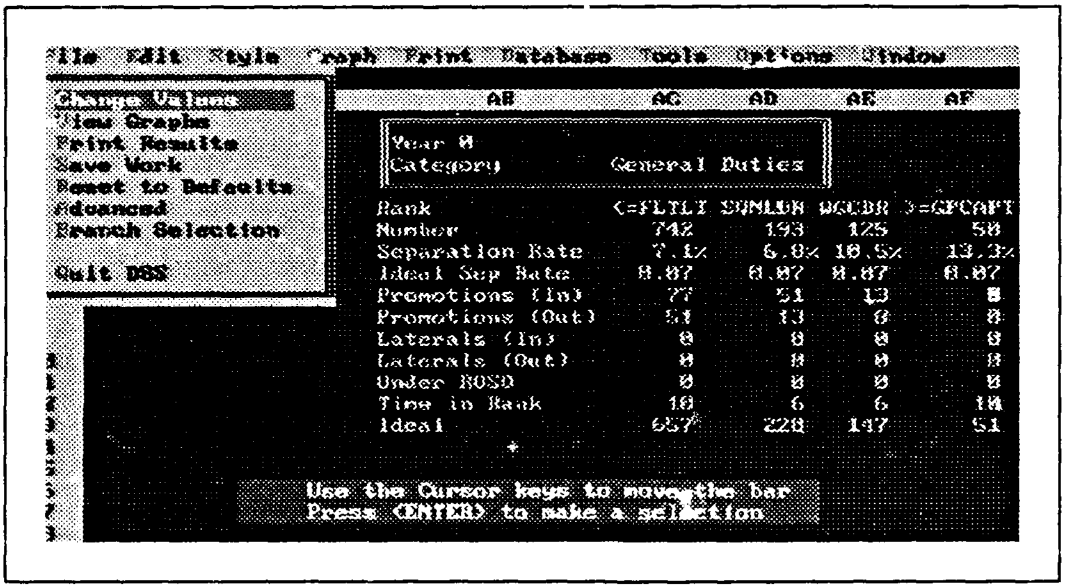

Figure **D-3** The Main Menu

From this main menu, choices are available to change the assumptions used in forecasting the future officer structure, view graphs of the forecasts, print out graphs or data, save the work done, reset the assumptions back to their default (historical values), use more advanced features or change the category of officer under consideration. The use of this menu is explained in the next section "Using the DSS".

The diagram below (Figure 4) shows the overall layout of the menu system. The structure has been designed so the more popular options are available on a number of menus to save the user having to continually climb and descend the menu tree. An example of this is the *View Graphs* option. This option is found on most menus as it seems logical a choice to want to view the forecasts after making a change to the system.

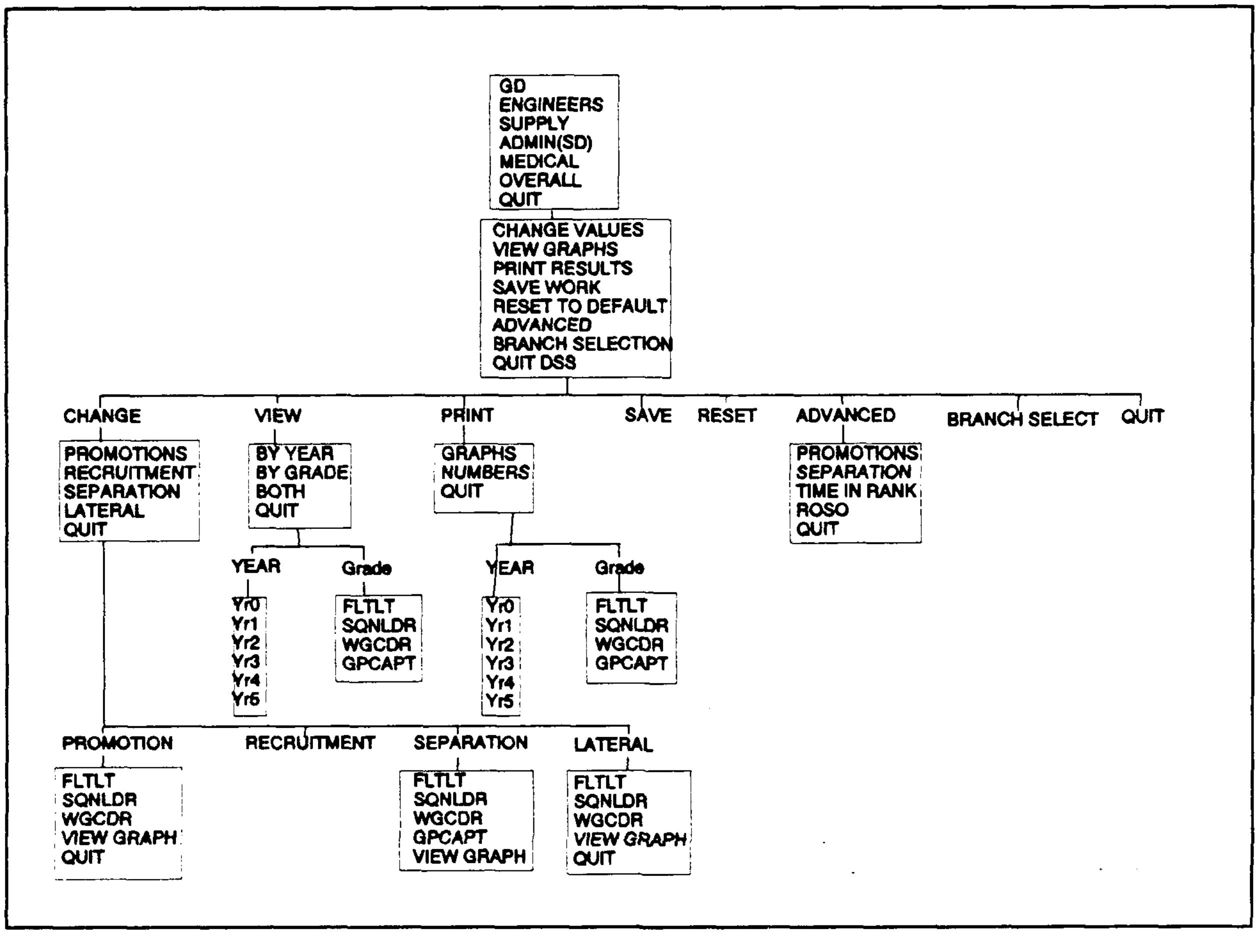

Figure **D-4** The Overall DSS Menu Tree

Using the DSS

The options available on the main menu are:

CHANGE VALUES

This option allows the user to enter a his/her own rate for promotions, separation, recruitment, and lateral movement rather than use the historical value.

PROMOTION This option allows the user to enter a different number of promotions from the one found in the historical database. The user is prompted to select the grade of officer and then the number of promotions from this grade to the one above. The number should be the number of promotions per year. The number entered is applied to all five

years in the future. An error occurs if the number is non-numeric or less than zero. Fractions are rounded to the nearest whole number in the processing.

RECRUITMENT The recruitment rate for the category or branch can be changed by the user from its historical value. The user is prompted to enter a value for the number of new entrants to this category per year. The value can be seen on the screen as the number of promotions into the FLTLT and below rank. The program assumes all members come in at that level. If this is not the case, the recruits should be entered at lateral recruits (see below).

SEPARATION The separation rate for each grade can be changed by the user from its historical value. The user is prompted to select the grade of officer and then the rate of separation from this grade. The number entered is checked and converted to a percentage for use in calculating future number of separations. The rate entered is applied to all five years in the future. An error occurs if the number is non-numeric or less than zero.

LATERAL The numbers of lateral recruits for each grade can be changed by the user from its historical value (normally assumed to be zero). After selecting a grade, the user is prompted to enter a value for the number of lateral recruits to this grade per year. The present value is highlighted as the present LATERAL IN value. Negative and non-numeric entries cannot be entered.

QUIT This selection will take the user back to the main menu.

VIEW GRAPHS

This option allows the user to view the present structure and see graphically the forecast for the future force from a number of perspectives. Included are the views by grade, year and overall.

BY YEAR This option shows all ranks in a given year. The year is initially Year 0 (the present force) and other years (Year 1 through 5) are selected by pressing the keys 1 - 5 or clicking on the buttons

on the screen. The years can be viewed in any order. Pressing Q or clicking on the Quit button will return you to the VIEW GRAPHS menu.

BY GRADE This option initially draws a graph of the FLTLT & below rank for the next five years. Views of other ranks is seen by selecting the first letter of the name or clicking on the button with the mouse. Pressing Q or clicking on the Quit button will return you to the VIEW GRAPHS menu.

BOTH This option selects a single graph which combines all of the information above, that is, it has all ranks for all years. It does not include the ideal values available in the other graphs.

QUIT This selection will take the user back to the main menu.

PRINT GRAPHS

This option allows the user to print the graphs above or print the actual numerical data from the model tables.

GRAPHS This option allows the user to print the graphs discussed above under VIEW GRAPH.

NUMBERS This option allows the user to print the actual tables rather than the graphs. The same by year or by grade options are available.

QUIT This selection will take the user back to the main menu.

SAVE WORK

Selection of this item from the menu will allow the changes made to the database to be saved. The user is prompted to enter a name for the file and then the data is saved. The name entered is shortened to 8 characters and has non-ASCII characters removed if present. To load the data that file is selected on the initial loading rather than DSS.WQ1. Use the BY-PASS option on the Branch selection menu to ensure values are not reset.

RESET TO DEFAULT

Selection of this item from the menu will reset all the changes that have been made back to the original historical values.

ADVANCED

The Advanced menu allows the user to enter different numbers of promotions in each year, enter different separation rates for each year, to enter a percentage of people under ROSO, and change the average time in rank for each grade. At

present only the Promotion option is available.

QUIT DSS

This selection will exit the user from the DSS. You remain in QPRO. To exit PRO select {file - exit} by pressing

/fx

To rerun the DSS press <ALT> and <M> simultaneously.

PROBLEMS

The DSS has been designed to handle errors and so the user should not be "thrown out" of the program. If however this happens the program can be restarted by selecting <ALT><M>. To continue working on the data select BY-PASS so that new data is not loaded and all values reset.

If the problem cannot be resolved, the authors of the DSS can be contacted at the following address:

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Vita

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	September 1991	Master's Thesis

4. TITLE AND SUBTITLE

A DECISION SUPPORT SYSTEM TO ASSIST MANPOWER FORECASTING IN THE ROYAL AUSTRALIAN AIR FORCE

5. FUNDING NUMBERS

6. AUTHOR(S)

Simon J. Kelly, Squadron Leader, RAAF

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Air Force Institute of Technology,
WPAFB OH 45433-6583

8. PERFORMING ORGANIZATION REPORT NUMBER

AFIT/GLM/LSC/91S-36

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This study considers a problem that faces Royal Australian Air Force (RAAF) manpower and personnel managers. Informed decisions on the future force structure of the RAAF officer corps can be made by managers if they have access to objective, valid, reliable forecasts. At present, the RAAF has no standard mechanism to perform forecasts--a variety of tools are used. Given the importance and cost of the manpower resource, one integrated forecasting tool would support manpower decisions greatly.

The aim of this research is to address the existing forecasting deficiency in the RAAF and provide an automated system to integrate current forecasting methods. A Decision Support System (DSS) is best suited to this task.

A prototype of the DSS, which contained the core modules of the system, was evaluated by RAAF manpower managers. They found the DSS a useful tool to assist them with decisions effecting the future force structure.

14. SUBJECT TERMS

Decision Support Systems, Manpower Planning, Manpower Modelling, Forecasting, Force Modelling

15. NUMBER OF PAGES

160

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

AFIT Control Number AFIT/GLM/LSC/91S-36

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